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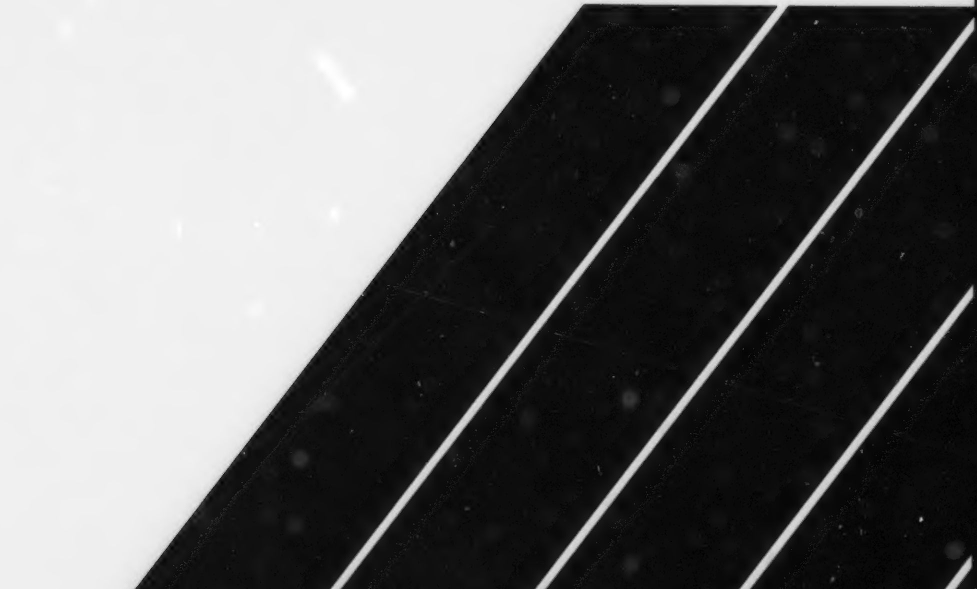

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TITLE:

REVIEW OF SELECTED CANMET PROJECTS: PHASE II FINAL REPORT

EXECUTIVE SUMMARY

BY: BRYSTRA CONSULTANTS

Work on the project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology; Mineral and Energy Technology Sector; Energy, Mines and Resources Canada.

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EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

1. OBJECTIVES

This project was commissioned by CANMET. It has as its main objective the identification of the costs and benefits associated with a sample of research and demonstration projects.

Conventional benefit-cost analysis tends to place a heavy emphasis on aspects which can be quantified in monetary terms. While such an accounting framework has its uses, well-balanced public policy requires consideration of numerous other criteria. This study has, therefore, also considered the development of more sophisticated criteria for project assessment, especially in terms of technology transfer and broad social benefits. The study reviews the socio-economic impacts of a sample of recent CANMET projects. Quantitative and qualitative benefits and costs are assessed.

2. MAJOR ISSUES

There were three major issues:

1. Does consideration of broad social impacts alter judgements about appropriate investments from decisions made with more narrow conventional benefit-cost assessments? If so, is there any systematic pattern which can be identified, so as to better inform investment choices?

2. With the benefit of hindsight, is there any pattern in the impacts of time on judgements about the relative success of various projects?

3. What management methods or criteria appear to produce the best returns on taxpayers' investments in the development and transfer of technology?

For each project, we started with the questions of "What were the original assumptions and expectations?" and "How well were they met?" "What costs and benefits were originally foreseen, and were any unforeseen costs and benefits realized after the project was underway?"

Numerous lesser issues have arisen, especially within each case. Since this contract was directed to learning the larger lessons from the multiple cases, there is little emphasis on singular case results – unless they serve as critical cases to inform the broader discussion.

This study examined eleven quite different cases, and tested them against numerous criteria of fairness, efficiency, and economy. It also examined the degree to which potential benefits have been realized, and the effectiveness of various management techniques in maximizing the taxpayers' returns.

There are no hard-and-fast rules against which to judge these cases, but there are guidelines. The special nature of the research and development (R&D) process infuses the analyses. R&D can be a very high leverage activity, yet many parts of its management remain poorly understood and only intuitively controlled. CANMET's experience is broad and informative in this special field.

3. METHODOLOGY AND APPROACH

After a series of interviews with the relevant CANMET project managers and other participants, we developed a list of indicators of costs and benefits. In some cases, micro-case studies of several sub-projects or participating organizations were conducted in order to collect data.

The diversity of the projects required that the case studies be tailored to the specific characteristics of each project. For example, projects that created information clearing houses or networks are quite different from those that generated products or technologies which directly reduce energy consumption or improve mine production levels.

Where feasible, net present values and rates of return were identified. This assessment, however, has been done in both quantifiable and qualitative terms. In several cases, anecdotal evidence suggested very large benefits, but no valid means was available to extrapolate from those instances to the population of other participants.

In all cases, we found that the normal financial ratios, taken alone, misrepresented the project's value. Thus, while financial data have been presented, other material on social impacts and non-financial criteria for both social and business decision-making has also been incorporated.

4. HISTORY

Phase I of the review was conducted by Peat Marwick Stevenson Kellogg in 1988-90. That phase provided cost-benefit analyses of nine other CANMET research and development projects.

The present project was tendered on November 29, 1990, with replies due by January 9, 1991. The contract was awarded on March 15, 1991 to Brystra Consultants of Waterloo, Ont. It has been managed by Diane Lamoureux of Supply and Services Canada,[1] with work being supervised by Robert Sauvé, of CANMET's Research Program Office in Ottawa.

Brystra's principals on this project have been: Dr. Robin Reenstra-Bryant (Vice-President) and Dr. Tom Bryant (President). We have been aided on various parts of the work by M. Jean-François Villion of Le Cabinet de Relations Publiques National, Inc. of Montréal and Dr. Colin Hindle of Regina. The draft report was completed in January 1992.

5. THE CASE STUDY SUMMARIES

One page summaries of the key points in each of the eleven case studies are found in the Appendix to this Executive Summary. The major findings and conclusions are described in the following section.

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[1] Contract data: SSC File no. 039SQ.23440-0-9195.

6. SUMMARY OF FINDINGS AND CONCLUSIONS

This section provides an overview of the impacts the projects have had, in both quantitative and qualitative terms, and the overall conclusions.

Economic Returns

The Terms of Reference for this assignment requested the calculation of Net Present Values and Internal Rates of Return for each project. The Table on the following page summarizes those calculations. Each line is developed in more detail in the individual case study chapter. NPVs and IRRs could not be meaningfully calculated in many cases. In several cases where the ratios could be calculated, they only partly reflect the value of the projects. That standard financial ratios may be misleading has been confirmed here. The question which remains is: "Is there any pattern in the outcomes which would lead to useful management guidelines?"

Patterns of Outcomes

We examined the different types of activities included in this study to see if that affected the outcomes. The range of outcomes is very wide, when known, and does not appear to be patterned on the type of activity.

Similarly, the degree of knowledge about outcomes also does not seem to have any obvious correlation with the type of activity. We had expected that service activities might be better known, more routinized, than research activities. That does not seem to hold up either, although the research intensive activities appear to have the least certain short-term outcomes. Projects such as Weld Zone Corrosion, Gamma Ray Detection, and Revegetation of Uranium Tailings have relatively little to show yet in terms of quantifiable economic impacts, but they clearly have the potential for very large returns in the foreseeable future.

Summary of Net Present Values and Internal Rates of Return

Project	Types	Dates	Direct Costs[2]	NPV	IRR
Wood Waste Boiler	Contribution	1984	$868K	>$700K	>30%
Solarwall	R&D, demo	1984-	$2,100K	>$2,400K	positive
Split Set Slings	R&D, demo	1987	$11K	$3450K	ca 4000%
Gamma Ray Detection	R&D, demo	1980-88	$1,700K	N/A	positive
CANSPECS	Service	1980-	$1,500K	$millions	>100%?
Tailings Revegetation	R&D, demo	1970-80	$3,000K	unknown	positive
Mine Conveyor Belts	Service	1987-	ca $1,100K	unknown	N/A
Intl. Stds. Setting	Service	ongoing	ca $2,000K/yr	unknown	N/A
Image Analysis	Service	1983-	$4,250K	$millions	over 100%
Mobile Foundry Lab	Service	1984-87	$2,200K	a: $1,000K b: $3,000K	10.5% (4 yrs) 25% (6 yrs)
Weld-Zone Corrosion	Research	1984-89	$640K	a: -$441K b: +$459K	negative +9%
TOTAL			$17,369K +$2,000K/yr.	large	large

Similarly, there does not appear to be a useful correlation between the magnitude of the investments and either the magnitude or the likelihood of paybacks.

Despite the small sample of only eleven projects being reviewed, it is surprising that several aggregate data hypotheses seem to have been refuted. It is clear from this analysis that many broad generalizations about CANMET investments and their returns are likely to be unfounded. That finding leaves us with a more limited opportunity to draw insights from the case studies.

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[2] Calculated in 1990 dollars, converted according to StatsCan's normal inflator-deflator tables.

Case-Level Insights

At the case level, there are several useful insights. The cases are organized here in what is often perceived to be an ascending hierarchy of development:

A. Research;
B. R&D with demonstration;
C. Post-demonstration incentive contribution;
D. Market-oriented services; and
E. Regulated or Public Goods Services.

The Summary Table on the following page has been re-organized in the same manner.

A. Research

The research project, Weld Zone Corrosion, has produced definable benefits. It has created new technological capabilities. Most of its value remains latent, however, as there have been very few uses for the technology yet. Major uses are possible and significant improvements in its payback might occur in the next 5-10 years. As research goes, the present status seems good, and the prospects excellent. As applied R&D, which it was thought to be when it was begun, it has fallen well short of the expected benefits due to postponement of the projects to which it was to be applied.

B. R&D with Demonstration

Four other R&D projects were followed through to the demonstration stage. CANMET has been quite effective in stimulating new knowledge for applied purposes and carrying the technologies forward far enough in the development sequence to put effective pilot plants and demonstrations in place. In all four cases, however, it is important to note that "demonstration" means primarily technical demonstration, rather than market demonstration. CANMET's support carried through the proof of concept at the engineering level, with attached financial analyses. Only in the case of Solarwall

Summary Table (by type and start date)

Project	Type	Dates	Direct Costs[3]	NPV	IRR
A. Weld-Zone Corrosion	Research	1984-89	$640K	a: -$441K b: +$459K	negative +9%
B. Tailings Revegetation	R&D, demo	1970-80	$3,000K	unknown	positive
Solarwall	R&D, demo	1984-	$2,100K	>$2,400K	positive
Split Set Slings	R&D, demo	1987	$11K	$345K	> 100%
Gamma Ray Detection	R&D, demo	1980-88	$1,700K	N/A	negative
SUBTOTAL			$6,811K	>$2,745K	positive
C. Wood Waste Boiler	Contribution	1984	$868K	>$700K	>30%
D. CANSPECS	Service A	1980-	$1,500K	$millions	>100%
Image Analysis	Service A	1983-	$4,250K	$millions	> 100%
Mobile Foundry Lab	Service A	1984-87	$2,200K	a: $1,000K b: $3,000K	10.5% (4 yrs) 25% (6 yrs)
SUBTOTAL			$7,950K	$millions	large
E. Intl. Stds. Setting	Service B	ongoing	ca $2,000K/yr	unknown	N/A
Mine Conveyor Belts	Service B	1987-	ca $1,100K	unknown	N/A
SUBTOTAL			>$3,100K	unknown	N/A
TOTAL			**>19,400K**	**large**	**large**

did we see strong evidence of a market success, and that seems to have been well outside CANMET's involvement. Yet even Solarwall has struggled into the market at a rate much slower than expected by the engineers and financial analysts. The other cases show signs of the same problem, despite strong technologies which appear to be ready for huge markets. All have much potential, yet little seems to have been realized to date.

Economic success requires market success. And that means involvement with buyers' psychology, with corporate investment decisions, with service and support networks, with development of a delivery organization. Rarely do technology-based demonstration programs accommodate these additional steps. From these cases, it seems CANMET is no exception.

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[3] Calculated in 1990 dollars, converted according to StatsCan's normal inflator-deflator tables.

C. Post-demonstration incentive contribution

The Wood Waste Boiler project was justified as a capital contribution to spur adoption of a proven technology, in order to reduce national costs for imported oil and to increase security of national energy supplies. While those results were achieved, a much larger benefit occurred through an apparent demonstration effect, leading to the widespread adoption of the technology. In this case, the benefits are real and can be documented.

In our opinion, having evaluated several other demonstration programs supporting innovations in technology, this result should not be considered accidental. Effective demonstration effects appear to take place fairly often later in the adoption cycle than program planners expect.

D. Market-Oriented Services

Three cases could be considered as market-oriented services. CANSPECS, Image Analysis, and the Mobile Foundry Lab all make use of CANMET's technical expertise and equipment to provide specialized testing and research services for an industry. CANSPECS provides calibration services for the coal testing labs. Image Analysis provides highly specialized analytical services for the hard-rock mining industry. The Mobile Foundry Lab provided process and chemical analyses for foundries, primarily small and medium sized ones without their own lab facilities or technical expertise.

CANMET's position in providing these services is somewhat delicate. It tries to offer new services which have high leverage returns for industry. They must be both substantially different from existing commercial services and sufficiently broad to warrant public agency involvement, yet they must also be highly effective. All three programs appear successful on these criteria -- a remarkable feat.

While costs are quite well-defined (for both CANMET and other participants), benefits are largely unknown. They are expected to be substantial and real, but the data either haven't been collected or are so confidential that we didn't see signs of them. This lacuna makes it difficult to substantiate the benefits. It also makes it very difficult to answer important management questions about the relative efficiency of different service modes and leverage points. Accordingly, organizational learning can only be intuitive and based on individual situations.

The benefits for CANSPECS and Image Analysis appear to be positive, even without extrapolation from our micro-cases to the whole user population. With extrapolation, the results are so positive that they generate very important lessons for public agencies. The value which appears to be added by these programs would be the envy of many public agencies – or private ones!

The Mobile Foundry Lab is a more controversial case. It was clearly uneconomic for the public agencies which supported it, and was shelved after 1987. An assessment at the time of the program found substantial economic gains to Canada resulting from the work. Yet that study apparently failed to consider displacement effects and total program costs in estimating the benefits, probably overstating the benefits . Our re-examination found no residual incremental benefits being claimed by the industry, although neither the users nor we were able to make any definitive examinations of the program's incremental impacts. Nonetheless, it seems clear that the Lab was very successful in getting better knowledge to the industry, resulting in improvements to most participants' production processes. In a devastated industry, the fact that no new business was attributed to the improvements may be a reversed sign: simple survival has been an indicator of superiority in this industry in the last five years.

E. Regulated or Public Goods Services

The two remaining services, International Standards Setting and Certification of Mine Conveyor Belts, are different. They are not particularly market-sensitive.

In the first case, the service is provided more as an administrative obligation than as a productivity-driven activity. Economic returns are not a direct objective and little measurement of such outcomes is even attempted.

In the second case, activities are mandated by regulation and CANMET has the only test facility in Canada doing the work. In this case, there is substantial recovery of costs, although there appears to be a small public subsidy (i.e., incomplete cost recovery). Perhaps the latter is to ease the burden on the private sector of the costs of regulation, or to recognize the public benefits which underlie the regulatory requirement. Whichever is the reason, CANMET is certainly not extracting monopoly profits. In neither case are the benefits even calibrated.

Overall Summary

It is very difficult to generalize across such a wide range of project types and benefit values. Still, one can see that these eleven projects represent about $25-35 million dollars of Government and participant direct costs over the last 20 years.

They have already generated many millions of dollars of benefits, probably several hundreds of millions. Many are only partially developed on the benefit side, and almost fully amortized on the capital procurement side. The potential for further strong benefits is quite large.

At the same time, it is apparent that many of the economic benefits are not being realized because of a lack of follow-through by the participants. Thus additional latent benefits are probably at least as great again as the ones already achieved.

Environmental values appear to be strongly served in this sample of projects. There are very few environmental costs and many benefits, some of them quite large, tentatively measured in the millions or billions of dollars.

Health and safety benefits are relatively uncommon, and health and safety costs practically non-existent in this group of projects. In some cases, such as Gamma Ray Detection, the costs are not well known because they involve low-level long-term effects, a class of phenomena which is not yet well understood.

Health and safety benefits do appear as significant on about half of the projects reviewed; in only one (Mine Conveyor Belts) are they the dominant benefit.

Overall, these CANMET projects demonstrate strong leverage and potential for future improvements.

CONCLUSIONS

The following conclusions draw on all of the cases to provide insights about the state of technology development and management in CANMET. The discussion is presented according to key topics.

Outcomes Analyses

Projects are approved because their proponents satisfy authorities that the expected benefits are worth pursuing. In an environment such as CANMET's, new technologies or procedures must be developed in order to deliver the forecast benefits. In a research-strong organization, we should expect some outcomes to deviate from the forecast. Issues that are important enough to be worth trying to solve are often ones associated with a significant uncertainty. Thus, as research progresses, new evidence may reveal new issues or solutions which were not previously known. Some may be dead-ends, others tangential, and still others may produce major expansions. If all projects worked out as expected, it would show that only well-understood problems were being addressed, in turn raising questions about the value of their solution. Accordingly, a healthy and innovative organization should expect some results to deviate from expectations.

The historical reviews revealed a range of results, from highly stimulative work (many follow-ons) to projects which have not realized their potential. Five different types of outcomes were identified; some projects had more than one, based on different results for different objectives. Most projects have worked out more-or-less as expected, a significant accomplishment given the risks associated with innovation. The five outcomes are:

- HIGH LEVERAGE: CANMET funds triggered significant follow-on expenditures and further investments.

- TAKE-OFF: CANMET funds initiated a process which has since become self-sustaining growth, without further public funding.
- LOCALIZED BENEFITS: Specific benefits for a local area or industry, with little extension to other areas or sectors.
- STEADY DEMAND: CANMET has created a sustained activity which is apparently based on a stable demand.
- LESS THAN EXPECTED: At least one important expected benefit has not materialized in the time frame originally anticipated.

The table below illustrates the range as well as the consistency of CANMET's results, when each of the projects' results are compared to original objectives.

MEETING OBJECTIVES[4]

(Extent to Which Original Objectives Have Been Met)

Case	<<	<	as expected	>	>>
Wood Waste Boilers			***	*	*
Solarwall		*	***	*	
Split Set Slings		*	***		
Gamma-Ray		*	**	*	
CANSPECS		*	**	*	
Revegetation		*	****		*
Conveyor Belts			**		
Intl. Stds. Setting		*	***		
Image Analysis			**	*	
Mobile Foundry Lab	*	*	**		
Weld Zone Corrosion	*		**	*	
Tally	2	7	28	6	2

The only type of expected benefit which has a pattern of under-achievement is that of industrial spin-offs. This is the case with the Split Set Sling Trial project, Gamma Ray Detection, International Standards Setting Activities, Weld Zone Corrosion, and in some respects CANSPECS. In retrospect, the expectations for industrial spin-offs on these projects were quite vague, knowledge of the processes needed to realize them was inadequate, and few resources were allocated to deliver them.

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[4] These are subjective judgements, based on our understanding of original project expectations, formal and informal, and the present status of the project. Each '*" represents one objective.

The two objectives that fall far below expectations are the willingness of industry to pay the costs of the Mobile Foundry Lab, and the expected spin-offs of the Weld Corrosion research to the Canadian steel industry, arising from the Polar 8 and Hibernia construction projects which have yet to materialize.

One runaway success is the stimulation of follow-on research into groundwater effects of mine tailings, a result of the Elliot Lake revegetation study. Follow-on work to date is an order of magnitude larger than the original work, and still growing, despite having been a very minor objective of the original project. Interestingly, this growth of research reflects the project's failure to control the leaching problem with its relatively simple solutions, thus uncovering a much larger issue. Results of this sort should be expected in any scientific inquiry addressing significant new issues. The real surprise in this review is not the presence of such stimulating failures, but their infrequency.

The other very strong unexpected success was the multiplier effect on adoption of wood waste boiler technology. CANMET funding was not based on a demonstration effect, presuming that such work had already been done. Yet it is apparent that numerous other adoptions, including some export sales, have arisen from the Donohue installation.

This process raises some questions about our understanding of the "demonstration-adoption" process. Results on other demonstration programs have often been frustrating to program managers because adoption rates are much slower than expected.[5] Here we have a strong demonstration effect, despite expectations that it was no longer necessary. While this result may be based on particularly effective personalities or promotion, it is worth examining in more detail to see if a revamping of technology demonstration programs to cover later parts of the adoption cycle would accelerate transfer of new technology into industry.

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[5] Comments based on previous work in evaluation of technology transfer programs in energy and agriculture.

Overall findings show that the lack of a proactive agent has damaged the agency's impacts in some areas of technology transfer. However, active CANMET personnel have tended to continue to attract opportunities.

While CANMET partly reflects a broad malaise within the Canadian public sector with respect to the development of intellectual property, it has accomplished much. Creation of intellectual property appears to have been strong, and recognition of valuable technologies in industry has also been above average. Better definition of the agency's role as a generator and agent of technological change, combined with appropriate resources dedicated to maximizing those impacts, would make the agency even more effective.

Cost Recovery

For services that can be routinized, cost recovery has been implemented fairly effectively. For services like Image Analysis and Conveyor Belt testing, costs have been defined, prices set, and an effective business service created. Pricing seems to have been market-sensitive, recognizing alternative services as well as CANMET's special capabilities. In some cases, recovery may have more than covered operating costs; in others, a partial subsidy appears to have justification to reflect other corporate or governmental goals. Sustained programs have subsidies which match their justification, even if a precise value cannot be established.

Where it was discovered that unacceptable subsidies have been required (e.g., Mobile Foundry), programs have been suspended or restructured. This use of attempted cost recovery matches industry's use of various pricing mechanisms to develop empirical market information. "Sometimes, you only find out what it's really worth when you start charging for it."

Cost-Sharing

In other areas, effective cost-sharing relationships have been created. With CANSPECS, for example, all parties seem reasonably satisfied with the returns for their contributions, yet CANMET has no direct recovery of its costs. The same holds true of the Split Set Slings trial in Cape Breton and the Solarwall project.

Reviewing such cases as Image Analysis, Mobile Foundry, and Conveyors Belts, we were pleased to see a relatively sophisticated pattern of service development. In each case, an industrial need was identified, a service developed, introductory pricing initiated to build business, then a decision made to continue, contract out, discontinue, or restructure.

In the case of Image Analysis, capital costs have been carried by CANMET. Operating costs were subsidized by the START program for the first two years, and have since been carried by the mining industry.

With the Mobile Foundry, the introduction of limited cost recovery very quickly showed that the industry being served was not willing to pay anywhere near the full costs of the program. The program was then mothballed. One study at the time showed that indirect returns more than covered the deficit on the program; our current analysis shows no such return. (Any reintroduction of Mobile Foundry services in the future should consider options which significantly reduce operating costs while preserving the most valuable parts of the on-site service.)

CANMET's role in the testing of mine conveyor belts is primarily mandated by regulation. Operating costs are split with the industry, presumably because there is some general public good being served. Demand and operations appear to have reached a steady state.

We did not review any cases which suggested that cost recovery was designed to cover development costs as well as operating costs.

There appear to be some outstanding issues for the organization. The relationships among service provision for fees, public service, research, and new product/service development are still being worked out. Funding and performance guidelines do not yet appear to have dealt with this complex interaction in a sophisticated way.

The extent to which normal business practices, like "cash cows" funding new product development, apply to CANMET services is still unclear. It affects pricing as well as development. Yet the answers are not simple for a public sector organization. They are even more complex for an advanced technological organization, such as CANMET, where new developments are both expensive and risky. The potential for good ideas to lead into either windfalls or write-offs is very high. Treatment of both the risk and the rewards is needed to provide a sound financial framework as well as providing clear and fair direction and performance criteria to staff.

Other Types of Recovery

The Gamma Ray case was very important to this work because it revealed a second dimension of recovery models. By imbedding the gamma ray technology in a larger technology (CANMET Hydrocracking), then licensing the hydrocracking package, CANMET demonstrated another way to recover costs (or provide returns to investments in R&D). The creation of special technologies is clearly a CANMET strength, yet operating them as an industrial service is not always attractive either to users or CANMET. Licensing, with various royalty options, makes an attractive alternative.

Our overall review suggests that there is much more potential for this type of wealth creation and sharing than is presently being exploited. Indeed, it appears that some technologies (e.g., Split Set Slings, Mobile Foundry, Weld Zone Corrosion) could be producing much more valuable returns to CANMET and Canada if they were deliberately developed as licensable technologies and turned over to a proactive champion.

The whole area of public sector involvement in intellectual property is poorly understood and very under-developed at this time. Yet several models are being created and tested in various federal, provincial, university and private agencies.[6] There is significant potential for CANMET to increase its revenue, and to increase its contributions to Canadian industry, by developing a more effective push to get its technologies to market.

Roles for Partners

CANMET engages in many partnerships. Most involve co-funding arrangements. The terms and productivity of those partnerships are very diverse, as befitting so many different kinds of relationships. Yet there are some patterns which emerged from our case studies.[7]

Development of a specialized service capability, designed to support firms across an industry, makes service clients of the industrial partners. This model can be applied to Image Analysis, Mobile Foundry, Conveyor Belt testing, and may come to be the dominant model for the Gamma Ray capability.

In other cases, joint development of new technologies is one way to create new industrial capabilities in Canada. Solarwalls, hydrocracking (including Gamma Ray detection), Revegetation of Uranium Tailings, and Weld Zone Corrosion are all examples of efforts of this type. CANMET has provided funds, technical expertise, and specialized equipment in partnership with industrial efforts. Industrial participation is expected to lead to practical applications and demonstration of proof-of-concept. The challenge in these types of partnerships seems to lie more in the push to commercialize the results, rather than the creation of effective research projects.

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[6] Note the development of intellectual property and technology transfer mechanisms by the Agriculture Development Fund of Saskatchewan. Note also the creation and development of RockCliffe Research and Technology Inc. to spin out technologies from federal labs.

[7] From our point of view, this is a very healthy sign. Partnerships are organized to accommodate the specific capabilities and responsibilities of each participant to contribute to solving specific problems. While this way of doing business makes administration more difficult than standard programs and contractual arrangements, it is more focused and more productive.

Subsidies to stimulate industrial adoption of existing technologies is a third form of industrial interaction. It has been used in the cases of Solarwalls, Wood Waste Boilers, and Split Set Slings. Results have been mixed, largely due to variations in the presence of proponents and their effectiveness in pushing products to market.

Public Goods: Specific Functions

Public goods, such as security of fuel supplies, can be used to justify some unrecovered costs. On the Wood Waste Boilers case, for example, the primary justification would appear to have been the reduction of oil imports. Saving foreign exchange, as well as securing energy supplies from domestic production, would be the primary results. The result was a relatively modest contribution of 10% of the capital costs for installation of a proven technology. (The fact that the St. Thomas Didyme installation appears to have become a highly productive demonstration should be treated as a bonus, since it was not funded for that purpose.)

There are no direct recoveries from this sort of investment. The recoveries come indirectly, through domestic supply benefits, security (unpriced until required), environmental mitigation, employment (avoiding UI/welfare expenses, creating sales and income tax revenue), corporate taxes on increased production, more intensive use of resources, etc. Those recoveries are rarely calculated rigorously.

Public Goods: Diffused Functions

CANMET's contributions to International Standards Setting merit special comment. This case was the most difficult for us to assess. The function is spread throughout the organization and is generally not treated as a

Centre-wide organized activity. It does not have a specific direction, accounting, or reporting focus. While assigning it 1.5% of CANMET's PY allocation makes certain costs calculable, those numbers should have fairly wide confidence bands placed around them.

The most difficulty, however, was encountered in trying to assess benefits in a systematic manner. They are almost all intangible or anecdotal. Even if one was able to quantify a economic benefit from CANMET participation in an international standards body, most such calculations would be trivial or misleading. As a result, we fell back to two qualitative measures. The first was to assess this activity as a type of pro bono or charitable contribution, using various corporate guidelines for comparison. The second was to compare the expected impacts of CANMET participation on economic order in Canada and our trading world with the magnitude of the associated costs.

The pro bono yardstick must be modified for public sector organizations. By their very nature, they function to fill socially valuable gaps in the private sector, and so are expected to have a much higher share of non-economic activity. Corporate standards, when articulated, seem to range from 1-10% of pre-tax profits, with an average goal around 2.5 to 3%. If we use a yardstick of 10% profit on gross revenues, the contributions budgets then becomes 0.3% of gross revenues.

What should be the comparable level for a public sector organization? There are no easy guidelines, except that we would expect it to be considerably higher, by virtue of the purpose of a public sector organization being to fill gaps in the private sector – often the unprofitable or unattributable gaps.

CANMET's International Standards Setting activities, at 1.5% of PYs, are not the organization's only unrecoverable contributions. While the comparison may suggest that this contribution is high, further examination clearly shows that the analogy is largely inappropriate. CANMET has numerous public goods rationales for playing the standards roles its does, and the recovery to Canadian society and industry in health and economic benefits can be quite large, if indirect.

CANMET participation appeared to be largely on well-organized and effective bodies. Their deliberations appeared to be focussed and efficient, producing standards which were widely adopted and helped to rationalize the related activities. In most cases the activities were worth far more than the standard setting costs. Thus, our conclusions, though necessarily vague and general due to the quality of the output indicators, were that the functions were being executed efficiently and professionally, and were likely producing quite high leverage for Canada.

That left us with a somewhat unsatisfactory sense of closure. Evaluation of this type of activity needs better yardsticks. Important questions couldn't be answered. How does one assess the consequences of increasing this activity to 3% of PYs? Cutting it to 1.0%? What are the leverages? How does management decide what is really appropriate? How does management even control and direct such a diffused activity? Such an inquiry is very complex, yet of great value for many public sector organizations. It is clear that justification lies in broad, indirect social benefits, rather than specific direct returns.

A Note on Industrial Intelligence

Part of the justification for participation in international standards setting has been the potential to gather information of competitive value to Canadian industry. As new technologies come before the standards bodies, valuable information about the technologies and optional techniques is revealed. Similarly, as standards are set, they will affect the costs and competitiveness of Canadian firms producing and buying affected products and services. With participation in those meetings, we create the potential to feed such valuable information to our industrial participants. Such an aggregative role is often used as a justification for public participation. Similar roles are routinely expected in the diplomatic and commercial services operated by External Affairs / International Trade.

To satisfy the terms of such support, the activities should demonstrate that this potentially valuable information is collected, processed, and distributed effectively. Unfortunately, there is little evidence that CANMET carries out this full function on any systematic basis. Some staff members undertake this work routinely through extensive interaction with industry, but the transfer process remains largely non-systematic and indirect. This broader role in technology transfer is not universally accepted or carried out. As a result, significant benefits to Canada are not fully delivered.

Impact of Social Benefits

In all eleven cases, the inclusion of social impacts, beyond the direct economic participation of CANMET, significantly strengthens the benefit-cost assessment. Additional social costs are minor, benefits substantial. In all cases, the direct benefits to CANMET are probably less than 50% of the identifiable value. Thus judgements about social value change in all cases for the better. Even in the worst financial case, Mobile Foundry Lab, where recoveries were less than 10% of costs, an earlier study argued that diffused social benefits in terms of increased industrial productivity and competitiveness more than made up the other 90% of costs. At the other end of the scale, the Image Analysis service has resulted in millions of dollars of investments and, we presume, in similar benefits to the industrial participants, their employees, customers, suppliers, and shareholders.

In all cases, precise (or even vague) estimates of value were impossible. What turned up was anecdotes recounting differences in contracts won, businesses saved, plant lives extended, etc. In most cases, even one or two anecdotes would be sufficient to offset the CANMET deficit. There were many such anecdotes and most projects had dozens of clients who appeared satisfied by their experiences.

For analysts used to rigorous, quantified analyses, this level of evidence is far from satisfying. Yet it is the level of evidence available. Using it effectively requires several conditions:

- Examination for trends: i.e., are all anecdotes in the same direction, or do they offset each other, with some being net benefits, others net costs?
- What is the magnitude of the claims?
- What is the likelihood that anecdotes apply to other participants not interviewed? To greater or lesser degrees?
- Are the benefits net of participant and CANMET costs?
- To what extent can effects be attributed to CANMET intervention?
- Should the benefits to one participant be recorded as costs or benefits to other groups in society? If so, to what degree?

To the extent possible in each situation, we tried to examine claims from these angles, to satisfy ourselves about the net effects on Canadian society. While the logic was sometimes fuzzy, and the risks of double-counting often present, we concluded that external social benefits were likely considerably higher than direct returns.

Unexpected Impacts

External events have sometimes significantly affected the benefit function of these CANMET projects. The Weld Zone Corrosion work, for example, was at least partly justified on the basis of expected steel sales for the Polar-8 icebreaker project and the Hibernia offshore development. When those projects were shelved, the research benefits were deferred indefinitely, vastly reducing the expected payoff.

Conversely, heightened concerns about uranium effects and low-level environmental dosage effects in the 1980s has made the early work on revegetation of uranium mine tailings more valuable than expected. Not only were many of the solutions already underway, but the remaining research agenda was much better defined. The value of those benefits may have been anticipated twenty years ago, but was probably understated compared to public concerns in the late 1980s and early 1990s.

A Learning Organization

CANMET has demonstrated the ability to innovate and learn, trying new ways of delivering benefits to its clients, and dropping or restructuring those which cannot be justified. It has also shown market sensitivity in establishing its recovery policies and prices, recognizing not only related competition, but also the value added by the expertise of its professional staff and specialized equipment. While wrestling with some very complex issues in technology transfer, CANMET has shown flexibility and innovation in developing new approaches.

There is room for continued improvement. Tracking social benefits is important to CANMET in order to measure more accurately its real contribution to Canadian society. Increased attention to proactive means of creating the wealth inherent in its research and development projects could add significantly to the value the organization contributes. Further development of the rationales for various levels of public support would aid program managers with decisions about allocation of costs, and hence about the level and type of external support required to sustain programs. Rudimentary models appear to be in place in each instance; now it is time for more detailed and accurate development of these management tools.

APPENDIX

CASE STUDY SUMMARIES

SUMMARY:

WOOD WASTE BOILERS

Installation of two wood chip boilers at the Donohue sawmill at St. Thomas-Didyme, Québec. The boilers replaced one oil-fired boiler, and were fueled by existing wood waste products.

Total Capital Cost: $671K (1984$)

EMR share (through FIRE): $68.7K

Participants: Donohue St-Félicien Inc. and EMR.

Status: Two boilers installed in 1984-85; operational since 1986. Four additional boilers installed in other Donohue plants since then.

CANMET/EMR Role: Financial support for the installation of the original two boilers under the FIRE program.

Benefits: Doubled production of dried lumber, increased share of US market; saved costs of waste disposal; lowered fuel costs; spurred further investment.

Other Features: Effective market demonstration of technology; promoted export sales of technology and products; expected benefits of energy security have diminished with falling world oil prices; unexpected benefits of environ mental integrity have arisen from market changes and social value shifts.

(p. 9)

SUMMARY

SOLARWALL

Support for demonstrations of a solar heating and ventilation system for industrial buildings.

Cost of Program: $387K/year between 1984 and 1988 (1990 constant $).

Cost to CANMET: $201K/year between 1984 and 1988 (1990 constant $).

Participants: CANMET, Conserval Engineering,Inc., and 10 companies in southern Ontario.

Status: Demonstrations enabled the manufacturer (Conserval) to sell Solarwall systems to other plants, and to make sales into the United States.

CANMET Roles: Partial support for ten installations, and the monitoring of the success of the technology.

Benefits: Enabled manufacturer to make ten initial sales and to demonstrate various ways in which the technology can be adapted to different buildings.

Other Features: Displacement of energy supplies in favor of solar; improvements in work place quality; creation of new jobs based on Canadian technologies; export sales; new manufacturing taxes; GST revenues; and creation of new Canadian industry.

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SUMMARY

SPLIT SET SLING TRIAL

Testing of new technology to stabilize the roofs and their supporting structures within underground coal mine gateroads.

Cost of Project (1987): $9.300

Cost to CANMET (1987): $5,000

Participants: CANMET (Cape Breton Coal Research Laboratory) and Cape Breton Development Corporation.

Status: The demonstration was executed in 1987. Results are transferrable to other underground mines with similar situations.

CANMET Roles: Assistance with the research and development of the trial techniques.

Benefits: The trial demonstrated a new technique for strengthening the roof structure of underground mining roadways; allowed production levels of $144K/day of extracted coal to be maintained, instead of $72K/day and less over time without the sling sets; avoided expenditures for redigging gateroads at a cost of $1000/metre; and increased safety for workers.

Other Features: Significant improvements in productivity, health and safety. Relatively low cost technology. Applicability depends on geological conditions.

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SUMMARY

GAMMA RAY DETECTION

Research undertaken to develop the capability of measuring fluid dynamic phenomena in hydrocracking reactors operating at high temperatures and pressures, i.e., on the inside of thick-wall steel reactors.

Cost of Project: not applicable; was a capital project in mid-1980s. No current costs.

Cost to CANMET: not applicable. Total value invested @$1 million.

Participants: CANMET, AECL, Petro-Canada, (SNC/Lavalin Partec).

Status: Research and development for a 2-phase process has been successfully completed. The technology was applied in a hydrocracking demonstration unit and is now incorporated in the licensed technology package. No commercial applications of are operating at the present time, due largely to low world prices for light crude feedstocks.

CANMET Roles: Provided funding for design and fabrication at AECL Laboratories; developed a pilot testing facility and carried out a pilot test; and worked with Petro-Canada on the larger demonstration of the techniques.

Benefits: Large potential benefits in terms of more efficient refining processes, export of technology, reduced demand for imported oil, and better utilization of Canadian heavy oil resources.

Other Features: Development in CANMET of recognized expertise in the design of gamma ray detection systems, and in the analysis of data produced from them. One version of technology was licensed to Petro-Canada for commercial development and sale as part of the CANMET hydrocracking technology package.

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SUMMARY

CANSPECS

Program for blind round-robin testing of coal and petroleum coke samples by 124 testing laboratories to promote consistent testing methodologies and results, and to generate a greater understanding among analysts of the different qualities of various types of coal and petroleum coke. Operating since 1980.

Cost of Program: $145K/year since 1980.

Cost to CANMET: $50K/year (1980-1991).

Participants: 124 testing laboratories in Canada and other countries.

Status: Established program with recognition from international standards setting bodies.

CANMET Roles: Administration of program, analysis of results, and use of results to promote Canadian coals and international standards in Canadian interests.

Benefits: Increased confidence in testing procedures among labs, approximately $3 million in savings for one participating coal user.

Other Features: Reduced emissions for coal users, private sector participation, despite costs and largely intangible benefits for most participants. Export advantages are not yet apparent.

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SUMMARY

REVEGETATION OF URANIUM MINE TAILINGS

R&D 1971-1980 on ways to revegetate uranium mine tailings at Elliot Lake, Ont. Additional reclamation research has continued since 1980.

Cost of Program: $300K/year (1990 constant $) for research on revegetation between 1970 and 1980.

Cost to CANMET: $224K/year (1990 constant $) between 1970 and 1980.

Participants: CANMET and Rio Algom Ltd.

Status: Revegetation R&D completed in 1978; further reclamation R&D continues to control acidity of soil.

CANMET Roles: Research and financial support, research equipment, analytic support, later funding for acidity control through the MEND program.

Benefits: Over 400 acres of mine tailings revegetated, aesthetic benefits, dust control including control of radioactive dust particles, surface stabilization, improved understanding of how to control acid-generating waste of mine tailings so that sites can be decommissioned. Value not yet known.

Other Features: Stimulated >$18.5 million of further research on acid control; ground water monitoring; the impacts of uranium radiation; and the development of water covers for mine tailings.

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SUMMARY

CERTIFICATION OF CONVEYOR BELTS FOR USE IN UNDERGROUND MINING

CANMET certification program to test the strength and resistance to fire of materials used in conveyor belts for underground mines.

Cost of Program: $25-29K/year for CANMET, offset by revenues of $35K, largely from foreign manufacturers. Manufacturers' costs are estimated at ca. $150K(1990$).

Gain to CANMET: $10,000/year net before current depreciation charges of ca. $4K.

Participation: CANMET, CSA and producers of conveyor belts.

Status: Ongoing testing program to allow producers to meet CSA specifications for their products.

CANMET Roles: Performs tests, authorizes certifications.

Benefits: Ensures that CSA specifications are met; improves safety of mines; provides protection for mining companies when buying conveyor belts.

Other Features: Primarily foreign users; $200K testing facility recently replaced with $20K facility, eliminating toxic fumes and depreciation problems.

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SUMMARY

CANMET INVOLVEMENT WITH INTERNATIONAL STANDARD SETTING GROUPS

Expert participation on committees and sub-committees; quasi-regulatory activities.

Cost to CANMET: over $1 million per year (based on 1.5% of operating & salaries costs for CANMET for FY1990-91).

Participants: CANMET officials, international standard setting organizations, and industry.

Status: Ongoing activities within several organizations.

CANMET Roles: Representing Canada; coordinating Canadian policy; provision of technical expertise.

Benefits: Collecting international knowledge and contacts for Canada; assisting in the setting of international standards for the advantage of Canadian industry; avoiding disadvantages for Canadian industry in terms of international standards.

Other Features: Professional development experiences for CANMET staff. Realization of industrial benefits could be enhanced.

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SUMMARY

IMAGE ANALYSIS

Technical advisory service, providing identification of minerals, mineral quantities and concentrations through electron microscope imaging. Part of CANMET's services and knowledge base in process mineralogy.

Cost of Program: $200K/year.

Cost to CANMET: Net operating profit of $50K/ year, not counting depreciation on capital equipment.

Participants: CANMET (Mineral Sciences Laboratories) and mining companies.

Status: Ongoing, technology and services being upgraded gradually as part of other on-going activities.

CANMET Role: Analysis on a fee-for-service basis.

Benefits: Better appreciation of characteristics of complex ores, leading to more appropriate technologies for recovery; higher recovery rates.

Other Features: High level of expertise established at CANMET; recognized by industry.

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SUMMARY

Mobile Foundry Lab

Development in 1984 of a mobile laboratory (on a truck base), assembled to travel to small and medium-size foundries across Canada. Staff of four included specialists who performed on-site analyses of foundry operations.

Timing: 1984, 1985 - CANMET delivery; 1986, 1987 - NRC/PROs.

Initial Capital Cost to CANMET: $323K (1990 $).

Cost of Program: $509K/year (1990 $).

Cost to CANMET: $417K/year (1990 $) for salaries and operating costs.

Participants: CANMET's mobile laboratory team visited 40 foundries in 1984, and 37 additional foundries in 1985. In 1986 and 1987 the mobile lab was operated by the Ontario Research Foundation (in Ontario and western Canada) and by the Centre de Recherche Industrielle du Québec (in Québec and eastern Canada). Roughly 20 foundries were visited in each of these two later years, including many of those visited in 1984 and 1985.

Status: The Mobile Foundry Laboratory ceased operation at the end of 1987. The lab was disassembled for lack of funding.

CANMET Roles: CANMET developed the laboratory, and operated it during 1984 and 1985. During 1986 and 1987, CANMET leased the laboratory to the two Provincial Research Organizations and provided technical expertise.

Benefits: Increased confidence for foundry operators; increased awareness of technical standards; small foundries able to bid on jobs requiring higher levels of quality.

Other Features: Industry devastated by contraction in late 1980s and early 1990s; program effect overwhelmed by external economic factors. Program revenue <10% of annual costs.

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SUMMARY

WELD ZONE CORROSION RESEARCH

Research undertaken in cooperation with the steel industry and manufacturers of welding materials to test the best composition of steel and welding materials for use on ice breakers (under cold, icy, salty, abrasive conditions).

Cost of Program: $107K/year during years 1984-1989 (in 1990 $).

Cost to CANMET: $32K/year during 1984-1989 (in 1990 $).

Participants: CANMET, Algoma Steel, Stelco, Canadian Liquid Air, Fleet Technology, Canadian Coast Guard, Lincoln Electric.

Status: Research was completed in 1990. Implementation deferred indefinitely due to weak market conditions.

CANMET Roles: Coordination of research, part of testing of welding materials for corrosion potential.

Benefits: Better knowledge of steel and weld compositions, and welding procedures that will reduce corrosion of weld zones under highly abrasive cold, salt water conditions.

Other Features: Some technology transfer to pipeline applications. Research was begun with high expectations for application to polar ice breaker and Hibernia oil rig construction. Indefinite postponement of those programs has limited the value to repairs and innovative new applications, such as pipelines.

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CANMET

Canada Centre for
Mineral and Energy
Technology

Centre canadien de la
technologie des
minéraux et de l'énergie

Energy, Mines and
Resources Canada

Énergie, Mines et
Ressources Canada

Canada

THE ENERGY OF OUR RESOURCES · THE POWER OF OUR IDEAS

L'ENERGIE DE NOS RESSOURCES · NOTRE FORCE CREATRICE

TITLE: REVIEW OF SELECTED
CANMET PROJECTS: PHASE II
FINAL REPORT

BY: BRYSTRA CONSULTANTS

Work on the project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology; Mineral and Energy Technology Sector; Energy, Mines and Resources Canada.

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MICROMEDIA

REVIEW OF SELECTED CANMET PROJECTS

PHASE II

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CHAPTER 1

INTRODUCTION

INTRODUCTION

1. OBJECTIVES

This project was commissioned by CANMET. It has as its main objective the identification of the costs and benefits associated with a sample of research and demonstration projects.

Conventional benefit-cost analysis tends to place a heavy emphasis on aspects which can be quantified in monetary terms. While such an accounting framework has its uses, well-balanced public policy requires consideration of numerous other criteria. This study has, therefore, also considered the development of more sophisticated criteria for project assessment, especially in terms of technology transfer and broad social benefits. This study reviews the socio-economic impacts of a sample of recent CANMET projects. Quantitative and qualitative benefits and costs are assessed.

2. CONCEPTUAL FRAMEWORK

Extensive effort has been directed to the development of new technologies that will optimize the use of Canada's mineral and energy resources. Those techniques have sometimes been developed, however, without full consideration for the balance between socio-economic costs and benefits. Further efforts to develop new ways of preserving our natural resources, and efforts to expand the adoption and implementation of known technologies will be dependent on a thorough understanding of the costs and benefits that follows from them.

The impacts of these technologies need to be assessed for their influence on populations other than immediate consumers and users. Where impacts have been assessed, they have tended to focus on the immediate quantifiable economic considerations. Furthermore, traditional evaluation methods have not adequately quantified the societal benefits and costs of products. As a result, many cost-benefit assessments have been made on the basis of the individual benefits and costs to the technology user without consideration for the broader impacts on society. There is an ongoing need to develop evaluation methods which more fully incorporate social values, in order to determine the actual value of these technologies.

Additionally, cost-recovery has at times become a program objective without full consideration of: what costs need to be recovered; the potential to achieve reasonable recovery of costs (currently or in the future); or the appropriateness of different forms of cost-recovery for the program at hand. In the same way that government support for demonstration projects is often justified on the basis of the economic activity they stimulate, other fees attached to other programs or services can be evaluated for the economic benefits they produce.

In particular the incidence of costs and benefits may extend far beyond the direct participants, raising other issues about the fairness of recovery measures directed only to those immediately involved. The appropriate trade-offs between charges to direct users and transfers from general revenues merits continued exploration. While theories of political economy make distinctions between beneficiaries, practical applications will require testing on numerous cases.

This study goes beyond immediate financial impacts, and considers, where appropriate:

- opportunity costs,
- qualitative indicators of costs and benefits,
- financial returns on project investments,
- break-even periods, and
- the likelihood of paybacks in a five-to-ten year span.

It examines eleven quite different case studies, and tests them against numerous criteria of fairness, efficiency, and economy. It also examines the degree to which potential benefits have been realized, and the effectiveness of various management techniques in maximizing the taxpayers' value received.

There are no hard-and-fast rules against which to judge these cases, but there are guidelines. The special nature of the research and development (R&D) process infuses the analyses. R&D can be a very high leverage activity, yet many parts of its management remain poorly understood and only intuitively controlled. CANMET's experience is broad and informative in this special field.

3. METHODOLOGY AND APPROACH

For each project, we started with the questions of "What were the original assumptions and expectations?" and "How well were they met?" "What costs and benefits were originally foreseen, and were any unforeseen costs and benefits realized after the project was underway?"

After a series of interviews with the relevant CANMET project managers, we developed a list of indicators of costs and benefits, and the ways in which those indicators could be measured. After reviewing the indicators with the CANMET project managers, we carried out the project assessments. In some cases, micro-case studies of several sub-projects or participating organizations were conducted in order to collect data for the project/case study. Sensitivities to project assumptions have been taken into account, as have any unique features likely to affect the transfer of technology.

The diversity of the projects required that the analyses be tailored to the specific characteristics of each project. For example, projects that created information clearing houses or networks are quite different from those that generated products or technologies which directly reduce energy consumption or improve mine production levels. The nature of a technology and the end users of a technology also influenced the way in which costs and benefits were assessed.

Where feasible, the net present value of the project was identified. This assessment, however, has been done in both quantifiable and qualitative terms, due to the fact that qualitative factors are extremely important. Internal Rate of Return (IRR) calculations have not been possible or meaningful with most of the 11 projects, due to the nature of the data and of the projects themselves.

In several cases, anecdotal evidence suggested very large benefits in one or more sub-projects, but no valid means was available to extrapolate from those instances to the population of other participants. Similar benefits might be occurring for other participants, but we could not determine the degree without tracking each case; extrapolation from sample to population was not legitimate.[1] That said, one can be reasonably sure that other benefits are accruing; we just could find no way to estimate them accurately without considerable additional research beyond the resources available for this assignment.

In all cases, we found that the normal financial ratios, taken alone, misrepresented the project's value. Thus, while we have presented the financial data to the extent we can, we have also presented other material on social impacts and non-financial criteria for both social and business decision-making.

Throughout our assessments, we have considered the extent to which proponents and society were willing to pay for the projected savings, and the value that they placed on the technology. This corresponds to the economists' concept of utility.

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[1] Largely because the samples very small, and were not selected in such a way as to include any type of representation.

We have also tried to take into account the opportunity costs to the developer of the technology and opportunity costs to society if the technologies are not adopted, although these estimates can be highly speculative. We included only those data for which reasonable confirmations could be obtained, although we have often noted how wide the actual range might be. The effects of widely divergent values on the conclusions are noted in several places.

Lastly, we considered the possible trade-offs made in the decision to adopt (or not) the new technology. The relative advantages for adopters will affect both the rate of adoption and the external social impacts such as worker displacement and environmental changes. In general, however, we stuck to historical data when measuring benefits and costs. The forecasting element was used primarily when we tried to derive the future potential of innovations which have yet to perform as expected.

4. MAJOR ISSUES

There were three major issues:

1. Does consideration of broad social impacts alter judgements about appropriate investments from decisions made with more narrow conventional benefit-cost assessments? If so, is there any systematic pattern which can be identified, so as to better inform investment choices?

2. With the benefit of hindsight, is there any pattern in the impacts of time on judgements about the relative success of various projects?

3. What management methods or criteria appear to produce the best returns on taxpayers' investments in the development and transfer of technology?

Numerous lesser issues have arisen, especially within each case, but these are the dominant ones for the assignment as a whole. Since this contract was directed to learning the larger lessons from the multiple cases, there is little emphasis on singular case results – unless they serve as critical cases to inform the broader discussion. The case studies are written in sufficient detail to present the case information, but are oriented toward the light they can shed on the overall issues.

5. HISTORY

The project was tendered on November 29, 1990, with replies due by January 9, 1991. The contract was awarded on March 15, 1991 to Brystra Consultants of Waterloo, Ont. It has been managed by Diane Lamoureux of Supply and Services Canada,[2] with work being supervised by Robert Sauvé, of CANMET's Research Program Office in Ottawa.

Brystra's principals on this project have been: Dr. Robin Reenstra-Bryant (Vice-President) and Dr. Tom Bryant (President). We have been aided on various parts of the work by M. Jean-François Villion of Le Cabinet de Relations Publiques National, Inc. of Montréal and Dr. Colin Hindle of Regina. The draft report was completed in January 1992.

The project originally consisted of thirteen case studies. Two were deleted due to insufficient information.

Phase I of the review was conducted by Peat Marwick Stevenson Kellogg in 1988-90. That phase provided cost-benefit analyses of nine other CANMET research and development projects.

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[2] Contract data: SSC File no. 039SQ.23440-0-9195.

6. RESEARCH ASSUMPTIONS

Each of the 11 case evaluations assesses socio-economic impacts based on:

1) A national perspective

While the 11 projects were undertaken on behalf of specific clients or for internal CANMET operations, we looked at the full scope of direct impacts to all entities across Canada who gain or lose significantly. To the extent that we could identify and document secondary impacts, we have done so.

2) Recognition that basic assumptions and project criteria at the time of the project are often different from criteria used for CANMET projects today.

Several of the projects included in this evaluation were initiated under other governments, under other parts of EMR, and under other CANMET policies regarding levels and types of industry funding (cost-shared work vs. facilitation without financial support). As a result, the impact of each project is considered in light of the criteria in place at the time of the work, and under current criteria and economic conditions.

3) Those benefits and costs attributable solely to CANMET efforts.

In most of the projects, there are third party participants (industrial clients, non-CANMET members of government committees, etc.). These third party participants may have undertaken extra efforts, outside the scope of the CANMET project initiative, which have influenced the impact of the project. In such cases, we have tried to differentiate the parts with CANMET involvement, and to examine solely the impacts that resulted from CANMET's efforts. We have reported costs and benefits to CANMET and other Government of Canada agencies.

4) Consideration of each project's non-quantifiable costs and benefits.

Qualitative effects (such as those relating to health and safety, environmental protection, energy and resource security, public information, worker health and safety, and the development of Canadian technological capabilities) are identified and developed for each specific project, as appropriate.

7. CAVEATS

The focus for this assignment was on lessons that CANMET could learn from its diverse experiences in technology management. We were not asked to conduct rigorous evaluations of the specific programs under which these projects were developed and administered. As a result, we have made relatively few conclusions or recommendations relating to the management of specific activities. We have concentrated on documenting those activities in such a way as to draw insights for the whole organization.

The non-comparable elements of the cases, from different time-lines, to different types of activities, to variable data quality, have made summary judgements quite subjective. We have tried to be as rigorous as resources permitted and as fair as we could be. As evaluators, we sought insights that could strengthen the efficiency and effectiveness of management.

CHAPTER 2

WOOD WASTE BOILERS

SUMMARY:

WOOD WASTE BOILERS

Installation of two wood chip boilers at the Donohue sawmill at St. Thomas-Didyme, Québec. The boilers replaced one oil-fired boiler, and were fueled by existing wood waste products.

Total Capital Cost: $671K (1984$)

EMR share (through FIRE): $68.7K

Participants: Donohue St-Félicien Inc. and EMR.

Status: Two boilers installed in 1984-85; operational since 1986. Four additional boilers installed in other Donohue plants since then.

CANMET/EMR Role: Financial support for the installation of the original two boilers under the FIRE program.

Benefits: Doubled production of dried lumber, increased share of US market; saved costs of waste disposal; lowered fuel costs; spurred further investment.

Other Features: Effective market demonstration of technology; promoted export sales of technology and products; expected benefits of energy security have diminished with falling world oil prices; unexpected benefits of environ mental integrity have arisen from market changes and social value shifts.

WOOD WASTE BOILERS

1. BACKGROUND

In 1984, Donohue St-Félicien Inc. installed two wood-waste-fired boilers at its St. Thomas Didyme plant to provide heat for the kiln drying of lumber. That sawmill annually processed 142 M cubic metres of lumber. The fuel for the boilers is planer shavings (3980 tonnes/year), collected on-site by a pneumatic system and delivered to a 570 cubic metre silo. An unloader delivers the fuel at the rate of two tonnes/hr. through a series of augers and hoppers, to be pneumatically injected into the top of the 5.3 GJ/h and 10.5 GJ/h Volcano boilers.

The fuel is injected in a swirl pattern to burn partially in suspension, with larger particles completing combustion on the grate below. Forced undergrate primary air is provided while exhaust gases pass to a multiclone dust collector fitted with a pneumatic fly ash reinjection system. Auxiliary burners assist combustion by burning No. 2 oil at 168 l/h in the 5.3 GJ/h boiler, and 341 l/h in the 10.5 GJ/h boiler. Low-pressure steam (207 KPa) generated at 226 kg/h (5.3 GJ/h boiler) and 4535 kg/h (10.5 GJ/h boiler) circulates to the kilns.

Installation of the two wood waste boilers was encouraged with support from the EMR Forest Industry Renewable Energy (FIRE) Program.[1] This project, like others supported under FIRE, was not viewed as a demonstration, but rather as a means of encouraging the adoption of an already proven technology.[1] Public financial support was justified at the time on the basis of reducing Canada's dependence on imported oil. Interestingly, while the energy security rationale has subsided in recent years with lower oil prices, other benefits have arisen in environmental mitigation. In addition, the site has been widely observed and appears to have served as an effective *market* demonstration project.[2] It has lead to several additional installations at other Donohue plants and at other sites in Canada and in export markets.

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[1] At the time of the installation of these boilers, the FIRE program was under the management and direction of the Renewable Energy Division of the Conservation and Non-Petroleum Sector of Energy, Mines and Resources. The program has since been reassigned to CANMET. As a result, references to EMR and CANMET are used interchangeably in this analysis.

Since the implementation of the project, CANMET's involvement has been to make summary information available to interested parties.

2. ISSUES

At first inspection this project appeared to be a straightforward example of how an alternative fuel could be utilized to reduce the consumption of oil. For this project, however, the alternative fuel is a waste by-product of the firm's primary production process. Thus, a waste disposal cost is converted to a fuel substitution saving.

Prior to the system changes, however, the alternative fuel did have some value to the sawmill operation, as the wood chips were sold for pulping. This analysis, therefore, addresses the extent to which these displaced revenues have been offset by the savings in oil costs.

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[1] The FIRE program was designed to spread the actual use of alternative energy technologies with recognized efficiencies and benefits; it was not intended to demonstrate the capabilities of these technologies. Both technological and economic benefits were considered to have been previously demonstrated.

[2] There continues to be considerable confusion in many R&D organizations about the different roles of technical (including economic) and market demonstrations. The former prove that an innovation works and can work economically. The latter prove those results to potential customers in such a way that rapid adoption is stimulated. The difference is very significant, as it relates to two very different audiences and anticipates two very different consequences.

The primary issue is the extent to which the expected benefits were realized. The secondary issue is the impact of more recent changes in markets, technology, and policy on the potential for further benefits from this technology.

3. METHODOLOGIES

This review is a cost-benefit analysis of this one project, which was funded under the FIRE (Forest Industry Renewable Energy) Program of CANMET/EMR. The focus of this review is the extent to which additional value has been realized by the installation of the wood waste boilers at this site. No attempt has been made to assess the merits of the full FIRE Program.

CANMET files were examined and CANMET program managers were consulted. In-depth interviews were also held with Donohue managers at their head office in Québec and at the Saint-Félicien plant (which oversees the St. Thomas Didyme plant where the boilers were installed). Unfortunately, much useful anecdotal knowledge of the installation was lost with the death of Donohue's program manager soon after the project was implemented.

EMR's Fact Sheet on the project has been used for many of the financial figures in this cost-benefit assessment.[1]

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[1] Cf. EMR datasheet entitled "Bioenergy Fact Sheet - Donohue St-Félicien Wood Waste Boilers," dated October 2, 1989.

4. FINDINGS

Costs

The Cost Function

The costs considered can be summarized as follows:

COSTS = Σ {(Capital costs of wood waste boilers)
+ (Installation costs)
+ (Increases in O&M costs)
+ (Lost sales of wood chips)
+ (Unused value of oil-fired boiler)
-- (Avoided costs of replacing oil-fired boiler)
+ (Health and safety costs)
+ (Environmental costs)}.

Capital and Installation Costs

According to officials at Donohue, the cost to install the two new wood chip boilers was $671K, including the CANMET contribution of $68K in 1984 dollars. These figures include labour to install the new system (contracted externally).

Operating and Maintenance Costs

CANMET project files suggest that annual operating and maintenance costs of the units are roughly $95K. A similar sum (or more) was likely being spent on O & M costs for the oil-fired boiler system. One technician was transferred to maintain the new boiler units, from the existing manpower at the St. Thomas Didyme complex. This was not an incremental cost to the plant, however. Donohue officials claim that no extra operating costs other than those included in the installed cost of the new units were incurred. It is, therefore, likely that the new wood-chip boilers had no **incremental** operating and maintenance costs.

Opportunity Costs (Lost Revenues from Wood Chip Sales)

CANMET project files suggest that the opportunity cost from displaced revenues from sale of the wood chips to pulping or chipboard companies was about $25K per year. However, Donohue management believes that an opportunity cost should no longer be charged for waste burned instead of being sold. The distance over which it can be economically transported is quite short and storage costs were substantial. There are very few industrial clients for this waste product within economic reach and the market is now considered saturated. Thus the issue of opportunity costs appears to be a matter of the point in time at which they are assessed.

Displacement Effects (Unused Value of Oil-Fired Boiler)

The two new wood-fired boilers displaced one older oil-fired boiler. We have assumed that the old boiler has remained in place as a backup unit. As a result, its remaining value has diminished considerably. Conversely, however, its replacement costs have also been avoided and maintenance costs reduced. Similarly, the company has received incremental benefits from this dual fuel capability. None of these values was estimated, but their net effect is believed to be slightly positive.

Health and Safety Costs

Donohue officials have reported that there are no health and safety costs associated with the new process: no increases in employee health care costs, or medical disabilities since the installation of the boilers. The same conclusion applies to the neighboring community.

Environmental Costs

Pollution levels at the sawmill are said to have decreased significantly. No environmental monitoring has been done, however, and neither the levels of pollution nor the factors contributing to decreased pollution could be documented.

SUMMARY OF COSTS

Item	year	1984 $	1990 $
Capital Costs*	1984-85		
CANMET		$69K	$89K
Donohue		$602K	$779K
Incremental Operating Costs**		0	0
Net Lost Revenues***		0	0
Displacement costs		– net beneficial –	
Health costs		nil	nil
Environmental costs		– net beneficial –	
Total Costs		**$671K**	**$868K**

Notes: *Installation was undertaken between 1984 and 1985. Operations commenced in 1986.

** CANMET data show that annual operating costs for the new system have been about $95K. Donohue officials argue that previous operating costs were about the same. There is thus no incremental cost or benefit in this category. Cf. "Benefits".

*** CANMET data showed lost revenues of about $25K annually from the sale of wood chips to pulp and chipboard clients. Donohue argues that the market for this by-product has since become saturated, and that storage, transportation and disposal costs would have exceeded any revenues. Cf. "Benefits".

Benefits

The Benefit Function

Benefits considered were as follows:

Benefits = Σ {(Fuel cost savings)
+ (Increased energy supply security)
+ (Savings on waste disposal)
+ (Value of environmental compliance)
+ (Value of increased production)
+ (Export earnings)
+ (Impacts of replication on other sites)
+ (Security of multi-fuel redundancy)}.

Fuel Cost Savings

By using wood wastes rather than oil as the fuel to provide process heat to dry lumber, a significant savings has been realized on fuel costs. CANMET data suggested that the net annual savings of $197K was realized (63% of earlier fuel costs), after taking into account the opportunity cost for shavings previously sold to pulping and chipboard companies. If the $24K attributed to lost revenue on the wood shavings is added back, the annual savings amount to $221K. Even at the lower current prices for No. 6 oil, Donohue estimates its savings at approximately 60% of the cost it would have otherwise incurred. This amounts to an apparent payback of approximately three years, without counting any other benefits.

Savings on Waste Disposal

While CANMET's earlier data suggested that there was an opportunity cost to Donohue in terms of the eliminated sale of wood chips, Donohue officials indicate that this has since turned into an actual savings for the firm. The market for wood shavings in the region has not been able to accommodate the total quantity of wood wastes produced by the sawmills. Thus there had been costs for storing, transporting and eliminating wood wastes in landfill sites. Those costs have now been eliminated.

Value of Environmental Compliance

There have been suggestions that the previous system might have exposed Donohue to additional costs as environmental regulations tightened. The wood fuel system avoids those costs. No specific data were obtained.

Increased Energy Supply Security

Dependent now on its own fuel sources, Donohue should be better able to forecast supplies. It should also be able to take remedial action more accurately if there is a supply shortage.

Value of Multi-Fuel Redundancy

By keeping some oil-fired capacity, Donohue has created a dual-fuel capability. That gives it increased security of supply, since it can now switch to the alternate fuel if there is a supply interruption. There are also some possible improvements in economics of supply, depending on relative prices for the two fuels. Like most insurance, neither benefit is expected to materialize, but the insurance is in place for both.

Production Increases & Export Earnings

By doubling the drying capacity (with two boilers rather than one), Donohue has more dried lumber to sell, and thus is more able to market its products in the United States. This production increase is the result of a larger volume of process heat being produced with the new boilers, rather than anything intrinsic to the heat source itself. If the project had been limited to one boiler, there would have been no increase in production levels. No values could be obtained for what increased U.S. exports means for the company, but the export earnings aid Canada's balance of payments with our largest trading partner.

Technology Transfer Effects - Impacts of Replication on Other Sites

Donohue has implemented the same conversion on several other plants in Québec. Numerous visits have been made to the Donohue plant by both Canadians and foreigners. Word-of-mouth data indicated that this project had helped to convince several other organizations, within Canada and internationally, to adopt the same technology. These adoptions have caused significant sales of boilers for the Québec-based manufacturer, Volcano. Unfortunately, the manufacturer recently ceased operations and the future of the technology was unknown at time of writing.

SUMMARY OF BENEFITS

Item	Value to date in 1990$
Fuel Savings (1986-91 -- $260K annually)	$1,560K
Energy supply security	some
Waste disposal	some
Environmental regulation benefits	possible
Value of increased production	considerable
Export earnings	some
Replication on other sites	considerable
Security of multi-fuel redundancy	potential
Total Benefits	**in excess of $260K per year now over $1.5 million in fuel savings alone.**

5. CONCLUSIONS

Net Present Value:	>$700K to the end of 1991; growing by > $260K per year.
Break-even:	<3.3 years.
Estimated Rated of Return:	>30%.

The oil-to-wood waste conversion has clearly been seen as beneficial by the owner, Donohue St. Félicien Inc. The company has implemented several similar conversions at other plants. The conversion has also allowed Donohue to increase exports, bringing new wealth into Canada.

CANMET's support was critical to the timing of the project. Although the proportion is relatively small (about 10% of capital costs), it was sufficient to improve the paybacks to Donohue to the point that the project was implemented at least two years earlier than would otherwise have been the case. It improved the forecast return from a "maybe sometime" category to a "do now" category. Without EMR's support, the project would not have met Donohue's internal investment criteria at the time, and it would not have proceeded, at least at the time it did. That timing had the fortuitous benefit of causing the project to proceed when its unexpected demonstration impacts were highest. The financial payback for Donohue St. Félicien Inc. turned out to be approximately three years based on its own financial contribution.

Despite not having been funded as a demonstration, this project had quite substantial demonstration benefits. Other units of Donohue have adopted the technology on the basis of this experience. Other companies have also made the adoption, based at least in part on their observation of the St. Thomas Didyme operation. International interest has been strong and some export sales by Volcano are thought to have occurred. This result suggests that a more detailed examination of the demonstration-adoption process may be fruitful.[1]

Since the project was funded at the level of approximately 10% of capital costs, and not intended as a demonstration, it would appear that CANMET's return has been substantially above expectations. The original objective of reducing foreign oil dependency has been accomplished, although present prices would reduce the current economic value of that accomplishment.

Improved economics have sustained plant viability at higher levels than would otherwise have been the case, thus avoiding social costs associated with unemployment and community disruption. Direct health costs and benefits are otherwise insignificant.

In addition, new environmental attitudes mean that the technology is delivering value not foreseen at the time of the installation. Environmental benefits are quite strong. Landfill disposal requirements and landfill storage hazards (including combustion and groundwater contamination) are dramatically reduced. As a result, a more sustainable and integrated operation now exists.

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[1] It has been our experience in various fields of technology stimulation that there is often one or two steps missing between what is expected to be "demonstration" and the rapid adoption of the technology by an industry. The somewhat unexpected leverage provided by this project suggests that it might be worth examining further.

CHAPTER 3

SOLARWALL

SUMMARY

SOLARWALL

Support for demonstrations of a solar heating and ventilation system for industrial buildings.

Cost of Program: $387K/year between 1984 and 1988 (1990 constant $).

Cost to CANMET: $201K/year between 1984 and 1988 (1990 constant $).

Participants: CANMET, Conserval Engineering,Inc., and 10 companies in southern Ontario.

Status: Demonstrations enabled the manufacturer (Conserval) to sell Solarwall systems to other plants, and to make sales into the United States.

CANMET Roles: Partial support for ten installations, and the monitoring of the success of the technology.

Benefits: Enabled manufacturer to make ten initial sales and to demonstrate various ways in which the technology can be adapted to different buildings.

Other Features: Displacement of energy supplies in favor of solar; improvements in work place quality; creation of new jobs based on Canadian technologies; export sales; new manufacturing taxes; GST revenues; and creation of new Canadian industry.

SOLARWALL

1. BACKGROUND

Conserval Engineering, Inc. of Downsview, Ontario is the developer of a solar heating system which is designed to produce and distribute heated ventilation air throughout industrial buildings. Southern walls of manufacturing facilities are equipped with solar collectors, roof-edge intake vents, ceiling fans and long lengths of perforated polyfabric ductwork. The actual components of the systems have evolved over time and are custom engineered for the particular installations.

Early installations included fibreglass walls mounted roughly one foot from the south-facing wall. In those systems, air which is trapped between the fibreglass wall and the building wall becomes heated and rises to a set of intake vents. From there the air is moved by fans and directed into the building through a flexible duct with perforations, through which hot air is released into the building at various locations.

Other installations are based on the same thermal dynamics, but include either dark-painted walls and roof overhangs for collecting hot air, or perforated, unglazed, metal walls positioned a foot from the main building wall structure. The perforated metal walls require less maintenance than either of the other two options. Roof overhangs with existing walls painted dark colours are less costly to install, with only slight reductions in performance when compared to the unglazed solarwall.

The three solarwall technology systems are thought to be the most cost-effective systems for buildings that have significantly stratified air temperatures or poorly insulated walls.[1]

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[1] Enermodal Engineering Limited, Active Solar Heating in Canada to the Year 2010. Report prepared for Energy, Mines and Resources Canada, 1990.

In 1984, Energy Mines and Resources Canada supported the installation of one of the first Solarwalls. Conserval Engineering Ltd. of Downsview, Ontario had been developing the technology since 1982, but needed assistance in making its first sales. Energy Mines and Resources provided 65% of the project costs for installing the wall at the Uniroyal plant in Kitchener.

The federal government contributions for the Uniroyal Solarwall were actually provided through the Solar Energy Development Program (SEDP), as were seven other Solarwall projects between 1984 and 1988. SEDP's objectives were to provide financial support for research development and demonstration projects in active and passive solar energy, small hydro, wind energy, photovoltaics and geothermal.

During 1988, the interdepartmental Panel on Energy Research and Development (PERD) became the funding program for Solarwall installation projects. This interdepartmental panel is chaired within Energy Mines and Resources Canada, and seeks to provide the science and technology for a diversified energy economy that is both economically and environmentally sustainable. Two further installations were partially funded through PERD.

During the period between 1984 and 1988, Energy Mines and Resources contributed to the costs of installing custom designed Solarwalls for ten facilities. The federal government has also contributed: some support for R&D on the Solarwall technology; the time of program managers; and subsequent funding for monitoring the energy efficiencies of these systems towards the development of this technology.

When federal government support for the installations ended in 1988, Conserval was making sales into the United States. At that time government support was considered no longer necessary. Financial support for installations at U.S. sites (and for U.S. companies) was also not considered to be an appropriate use of Canadian taxpayer dollars.

2. ISSUES

Installations of Solarwalls have, in most cases, been undertaken to improve ventilation and the heating of make-up air. Many of the plants that have adopted the technology have significant requirements for ventilation, and the Solarwall has provided a low-cost means of improving air circulation and heating replacement air. Other plants, however, have looked to the Solarwall for its potential to reduce drafts through auxiliary heating of air inside a large facility. These two different perspectives are important to keep in mind, as we consider the extent to which the benefits realized by the firms involved have met their original expectations.

The analysis of this project (federal support for the Solarwalls) is also concerned with the extent to which the costs involved with the production, installation and maintenance of the technology is sufficiently offset by the benefits of savings and other heating and ventilation system costs. The analysis also considers whether or not the system would make economic sense without federal government support.

The introduction of this technology can have significant impacts on worker satisfaction and health. The analysis has, therefore, also considered the extent to which the Solarwall installations have improved worker satisfaction, health and productivity.

3. METHODOLOGY

We have included in our interviews individuals at: CANMET (the Division of Energy Mines and Resources that has been responsible for managing the PERD assistance), Conserval Engineering, Inc., and a sampling of the firms where Solarwalls have been installed.

Appendix A includes a list of all of the Conserval installations to 1990, along with an indication of which ones received federal government support. In our analysis we developed a random sample of these firms, which resulted in five companies being selected for on-site intensive interviews. The five included three that received federal support for their installations, and two that did not. Interviews were conducted with the individuals who oversaw the installation of the Solarwalls in each of the five companies, and the operation of the plant after installations.

During the interviews with these five companies, we sought information on:

* their overall perceptions of value;
* initial costs (both direct and indirect);
* maintenance costs;
* financial benefits (energy dollars saved); and
* health, safety and worker satisfaction benefits.

Given the fact that each of the interviewed firms had installed different types of Solarwall systems, we were also interested in the systematic variations, why the different type of walls were appropriate at the time they were installed, and cost/benefit ratios in relation to the objectives of the particular installations.

Our interview with Conserval focused on the scope of their operations; the benefits they believe are inherent in the product; and the costs to install and maintain the Solarwalls. We also considered the extent of the federal government's involvement with the technology. Direct and indirect costs to the government have been identified. Benefits realized by the government are actually the same benefits that are realized by the manufacturer and the firms that have made use of the technology.

In several cases the companies that have installed the Solarwalls have not kept complete records of the costs (or savings) associated with this particular part of their operations. Assessments of costs, however, can be supported by auxiliary indicators. Similarly, the impacts of Solarwalls on worker satisfaction, productivity and health have not been strictly monitored by any of the firms, to date. Qualitative assessments have been made by plant facilities or engineering managers, however, which can provide useful indications of the impacts in these areas.

4. FINDINGS

Among the five firms that were contacted in our research, we found examples of each of the different types of Solarwall systems. Two had installed fibreglass (glazed) exterior walls; two had installed painted walls (or parts of walls) with collector overhangs; and one had originally installed a fibreglass exterior wall but had recently retrofitted the building with a newer, perforated, unglazed wall.

Reasons for installation of Solarwalls also varied among these firms. Corporate objectives included:

* improved air circulation in warehouse space;
* auxiliary heating for a high-ceiling manufacturing facility or facilities where large doors must be left open; and
* improved ventilation and pollution dilution for a manufacturing facility.

Each building was unique in terms of: internal usage, heating requirements, physical size, geographic location (affecting the amount of sun available), existing heating systems, as well as ventilation, insulation, and draft problems. Despite these differences, each company had come to the conclusion that a solarwall would solve some of its ventilation, air circulation and auxiliary heating problems.

Costs

The costs of the Solarwall program have been borne by the federal government, Conserval, the companies that have installed Solarwalls on their buildings, and the Ontario provincial government. Each of these costs is identified below.

The Cost Function

COSTS = Σ {(Federal government support for installations)
+ (Federal government support for R&D)
+ (Federal government support for monitoring installations)
+ (Federal government contract administration costs)
+ (Federal government support for testing prototypes)
+ (Conserval's share of matching grants for R&D work)
+ (The corporate shares of the installation costs)
+ (Provincial government support for installations)}.

Federal Government Support for Installations

Between 1984 and 1988, a total of roughly $541K (or $645K in 1990 constant dollars) was spent by the federal government on these ten installations, representing 49% of the total direct costs for the projects. Early projects were funded at a rate of 54% for federal contributions. The proportion of federal contributions applied to any project decreased over time, with the last CANMET-assisted installation receiving 33% federal government support.

Federal Government Support for R&D

Additional monies were also expended by the federal government in support of the development of this technology. Appendix B identifies the federal government's share of these other direct costs related to the development of this technology. In addition to the $645K that was spent to support initial installations, a further $136K of CANMET and National

Research Council funding ($178K in 1990 constant $) went to Conserval in support of the refinement and testing of the system and the development of a manual.

Federal Government Support for Monitoring Installations

Two other firms also received approximately $192K of public funding ($196K in 1990 constant $) to undertake the development of monitoring systems and actual monitoring of a few of the installations.

Federal Government Contract Administration Costs

During the same period, federal government administration costs for managing the R&D, installation and monitoring contracts totalled roughly $75K in current dollars (or $85K in 1990 constant dollars).

Federal Government Support for Prototype Testing

CANMET also paid $25K (or $32K in 1990 constant dollars) for the testing of Solarwall prototypes.

Conserval's share of matching R&D grants

Data on Conserval's R&D expenditures for the development of the three types of Solarwalls were not available. This analysis is, however, concerned primarily with that part of the R&D that received federal government support. Conserval's portion of cost-shared R&D efforts amounted to $103K (or $143K in 1990 constant dollars).

Corporate Shares of Installation Costs

Corporate payments to Conserval for the ten demonstration installations amounted to $561K (or nearly $770K in 1990 constant dollars).

Provincial Government Support for Installations

The Ontario provincial government contributed an amount of $15K (or $17K in 1990 constant dollars) to one of the ten projects.

Using 1990 constant dollars, the total federal government costs to help develop the technology and support the ten initial Solarwall projects was over $1.136 million (54.6% of the costs). Provincial government costs on these ten federally supported projects equalled $17K (.8%), and industry costs were approximately $928K (44.6%).

SUMMARY OF THE COSTS
(in 1990 constant dollars)

Costs to the Federal Government	
matching grants for 10 installations	$645K
R&D support for Conserval (NRC)	$131K
R&D support for Conserval (CANMET)	$47K
Support for monitoring some sites	$196K
CANMET internal costs for administering & monitoring the projects	$85K
CANMET support for testing prototypes	$32K
Costs for the Canadian economy	
Conserval matching R&D costs	$143K
Corporate share of 10 installations	$770K
Provincial contributions	$17K
Total Costs	$2,065K*

* Difference in total shown and the sum of the numbers presented is due to rounding.

Benefits

The Benefit Function

BENEFITS = Σ { (Jobs created at Conserval and its suppliers)
+ (Value of increased foreign trade)
+ (Value of increased domestic trade)
+ (Increased Tax Revenues to Canada)
+ (Value of saved energy)
+ (The value of reduced health risks, and increased worker satisfaction and productivity, through reduced air pollution in buildings with Solarwalls) }.

Jobs Created at Conserval and its Suppliers

As Conserval established a track record for installing Solarwall systems, the company was able to increase the number of employees hired. It reached the point where 10-15 jobs had been created for manufacturing and installation of the Solarwalls.

Increases in Foreign Trade

Foreign trade was increased through Conserval's sales to companies in the United States. Based on the success of its Ford, Oakville installation, Ford (U.S.) proceeded to install Solarwall systems in its plants in Buffalo, Cleveland, and two plants in Chicago. A total of $2,501K in foreign revenues ($2,701K in 1990 constant dollars) was realized by these contracts in 1988 and 1989.

Increases in Domestic Trade

In addition to its foreign sales, Conserval also generated an additional $1,473K in Canadian sales between 1988 and 1990 (after the federal government support for installations had ended). (This equals about $1.6 million in 1990 constant dollars.)

Increased Tax Revenue to Canada

The Government of Canada has realized additional revenues on personal and corporates taxes, covering about 100 PYs from 1984 to date, and corporate sales of over $5 million to date.

Energy Savings

While most companies have not kept records to show the amount and value of energy saved as a result of the Solarwall installations, there appear to be quite a wide range of energy savings experienced. At one end, one plant reported that it has not had to turn on its back-up (formerly its principal) heating system in two winters. This firm believes that the Solarwall is saving the firm about $75K per year in heating bills alone, and that at this rate the system will pay for itself in about two and a half years.

At the other end of the spectrum, some firms do not believe that heating costs have been affected at all by the Solarwall. They remain satisfied, however, because the system has provided improved circulation of air, and heating of fresh air. In plants that traditionally have had poor air quality, improved air circulation and the introduction of heated fresh air has an immense, though not measurable, value. In plants with large boilers as part of the production process, heating of internal air is not a problem at all. The Solarwall, however, has been able to provide a circulation of fresh air, eliminating the need to keep large doors open for extended periods. Air of a constant temperature is more evenly distributed with the Solarwall in these plants.

Value of Reduced Health Risks, and of Increased Worker Satisfaction and Productivity

While none of the plant engineering managers interviewed could document the effect that their Solarwall has had on health, safety or worker productivity, it was generally agreed that improvements had been realized in these areas. One plant engineer indicated that prior to the installation of the Solarwall, workers had not wanted to work in that particular building; since its installation, however, workers have been requesting transfers into the facility. Others believed that worker comments about air quality were reduced as long as the Solarwall fans were operational. Complaints of poor quality air increased whenever the fans were not working to circulate air in the building. One plant manager also believed that employee sick time had been reduced with the more constant temperatures that Solarwall had produced in their work environment.

SUMMARY OF BENEFITS

($ represented in 1990 constant $)

- 10-15 jobs created
- $2.7 million in foreign trade realized over 2 years
- nearly $2 million in Canadian sales generated to date
- $75K/year in saved energy costs for one plant
- others experienced some energy savings or improved air quality, worker satisfaction and worker productivity

5. CONCLUSIONS

The financial ratios for each of the participants in the Solarwall demonstration program are summarized below:

Participant	Costs (PV)[@]	Benefits (PV)[@]
NRC/CANMET	$1,136K	substantial[1]
Conserval	$143K[2]	>$4,300K[3] addl. sales
Corporate participants	$770K[4]	>$150K[5]
Govt. of Ontario	$17K	>0[6]
TOTALS	$2,065K	>$4,450K

[@] Reported in 1990 constant dollars, and rounded to the nearest thousand (000).

[1] No direct returns. Some value in deduced oil imports, hence security of domestic energy supplies. Also indirect values associated with earnings on exports, and more secure production and employment levels. Also indirect values associated with increased tax receipts from manufacturing and sales by Conserval.

[2] Contribution to cost-shared R&D. Does not include normal operating or project costs.

[3] Based on estimated total sales other than CANMET-supported projects. These sales and related expenditures were judged to be fully incremental since they would be unlikely to have occurred without the NRC/CANMET support.

[4] Corporate contributions to cost-shared installations, in which CANMET support was directly involved.

[5] Only one respondent identified specific monetary savings, amounting to fuel savings for space heating of $75K per year. We have included the two operating years to date. Most others reported their benefits in terms of environmental improvements and worker productivity, but without attaching financial values to them. It is likely that actual energy savings are very much higher than reported here.

[6] Should count provincial sales taxes, employment benefits, etc., but data were not known.

For the whole Solarwall demonstration program:

* Net Present Value: >$2,385K

* Break-Even/Payback: not meaningful. The costs are a mixture of research, development, demonstration, and adoption subsidies, spread over many years. Participants have different payback criteria and results. Corporate paybacks are usually less than three years for this type of project. Using a three year payback implies corporate benefits to the end of 1991 of nearly $4 million.

* Estimated Rates of Return: >100%. (Based on a cost base of $2,065K accrued over the first five years and benefits of $4,450K over the last three years.) Alternatively, using NPV of $2,385K over eight years, the rate of return would be 14.4% to the start of 1992 and climbing rapidly as benefits accrue without additions to the cost base.

During the five year start-up period, 1984-1988, CANMET was able to encourage a number of large manufacturing operations to install Solarwall heating and ventilation systems. By means of cost-sharing the installation costs for ten of the initial sites, Conserval was able to demonstrate that the Solarwall system has significant benefits. CANMET costs averaged just over $201K per year, and federal government costs in total (including NRC R&D support) averaged just over $227K per year.

These expenditures resulted in benefits worth many times that amount. Ten to fifteen new jobs were created by Conserval. Foreign trade has increased by $2.7 million since the demonstration support ended. As well, Canadian sales generated since the end of the demonstrations have totalled nearly $1.6 million.

While not all plants installing the Solarwall have done so for energy savings, or have realized energy savings, it is noteworthy that at least one plant has realized significant reduction in energy costs. This plant, in fact has documented its savings to be roughly equal to the annual cost to CANMET for the project. This plant alone will recoup its own Solarwall costs in two and a half years, and in another five years will have savings that equal the total amount that CANMET put into the program. Such savings indicate clearly the economic value of this technology.

Each of the plant managers interviewed was pleased with the results of the Solarwall installation. Each had different original objectives, and they have been realized. One company, in fact, has been so pleased with the results of the system for efficiently providing ventilation and replacement air that it has installed similar systems in four of its U.S. plants and in two other Canadian plants. This company has also returned to Conserval to have the newer unglazed perforated wall installed as a replacement for its initial fibreglass wall.

It is important to note that, for many plant managers, the value of the Solarwall has been its effect on worker satisfaction and productivity. While these are largely non-quantifiable impacts, they remain vitally important to the companies. Workers who want to be transferred to the Solarwall buildings now (but previously had tried to be transferred out of the same site), and workers who complain about air quality when the Solarwall fans are shut off, are evidence that the Solarwall system has increased worker satisfaction and productivity.

APPENDIX A

COST OF SOLARWALL INSTALLATIONS BY FUNDING SOURCE

(current $, 1984-1990)

Location	Year	EMR $	Prov. $	Company $	Total $
Trent Timber, Peterborough	1984	0	29,250	15,750	45,000
Uniroyal, Kitchener	1984	24,140	0	12,998	37,138
Sportsplex, Grand Falls	1985	51,935	0	27,965	79,999
Ranger Metal, Guelph	1985	41,040	0	27,360	68,400.
Ford, Oakville	1986	217,321	0	217,321	434,643
Indal Tech, Mississauga	1986	40,365	0	49,335	89,700
Bronte Park, Oakville	1986	0	0	10,300	10,300
Indal Furniture, Rexdale	1986	39,780	0	48,620	88,400
Manchester Plastic, Stratford	1987	36,450	0	49,450	85,900
Metcor, Montreal	1987	43,410	0	43,410	86,820
Bartell, Brampton	1988	24,000	0	44,700	68,700
Metcor, Fort Erie	1988	22,435	15,000	29,565	67,000
Ford, Buffalo	1988	0	0	723,240	723,240
Ford, Cleveland	1988	0	0	700,896	700,896
Dodge Chrysler, Dartmouth	1988	0	0	23,000	23,000
Mobil Chemical, Belleville	1988	0	0	77,000	77,000
Ford Assembly, Chicago	1988	0	0	89,376	89,376
Ford, St. Thomas	1989	0	0	668,000	668,000
Ford Stamp, Chicago	1989	0	0	987,840	987,840
McDonnell Douglas, Toronto	1989	0	0	200,000	200,000
Ford Windsor	1989	0	0	235,000	235,000
Hayes Dana, Stratford	1990	0	0	235,000	235,000
Totals		$540,876	$44,250	$4,551,127	$5,136,253

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*Note, additional installations have occurred since 1990, including a retrofitting of the Ford, - Oakville plant to incorporate the new perforated unglazed solarwall.

* Data source: CANMET project files.

APPENDIX B

FEDERAL GOVERNMENT COSTS ASSOCIATED WITH THE DEVELOPMENT AND INSTALLATIONS OF SOLARWALL TECHNOLOGY

(current $; 1990 constant $ shown in small type)

Title	Gov. $	Industry $	Total $
National Research Council R&D contracts to Conserval (1976-1982)			
Development of Solar Absorber for On-Site Assembly of Solar Panels	$28,980 ($41,375)	$28,980 ($41,375)	$57,960 ($82,750)
Refining Conserval Solar Air Handler and Solar Controller	$43,106 ($61,543)	$43,106 ($61,543)	$86,212 ($123,086)
Development of Prototype Solar Heated Air Make-Up System	$19,427 ($27,736)	$19,427 ($27,736)	$38,854 ($55,472)
Subtotal	**$91,513**	**$91,513**	**$183,026**
Subtotal (1990 constant $)	**($130,654)**	**($130,654)**	**($261,708)**
Energy Mines and Resources R&D Contracts to Conserval			
Experimental Testing of Unglazed Solar Walls	$20,135 ($22,156)	$6,712 ($7,386)	$26,847 ($29,542)
Refinement of computer model for estimating energy use of solar systems	$13,911 ($14,570)	$4,637 ($4,861)	$18,548 ($19,431)
Development of Conserval's design manual	$10,000 ($10,482)		$10,000 ($10,482)
Subtotal	**$44,046**	**$11,349**	**$55,395**
Subtotal (1990 constant $)	**($47,208)**	**($12,247)**	**($59,455)**

Energy Mines and Resources Contracts to other firms for monitoring of solarwalls

Field monitoring of solarwalls	$40,000 ($41,930)	$0	$40,000 (42,930)
Analysis of field monitoring data	$5,000 ($5,241)	$0	$5,000 ($5,241)
Performance assessment of an unglazed solar collecting wall McDonnell Douglas, Toronto	$47,843 ($47,843)	$0	$47,843 ($47,843)
Monitoring of new perforated wall at Ford, Oakville	$47,600 (47,600)	$0	$47,600 ($47,600)
Monitoring of canopy in solarwall at Hayes Dana, Stratford	$37,330 ($37,300)	$0	$37,330 ($37,330)
Modification of hourly simulation program used for monitoring solarwalls	$13,970 ($15,991)	$0	$13,970 ($15,991)
Subtotal	**$191,743**	**$0**	**191,743**
Subtotal (1990 constant $)	**($195,905)**		**($195,905)**

Other Federal Government Costs

Program Manager's time	$75,000 ($85,000)	$0	$75,000 ($85,000)
Testing of prototypes (1 month)	$25,000 ($32,300)	$0	$25,000 ($32,300)
Subtotal	**$100,000**	**$0**	**$100,000**
Subtotal (1990 constant $)	**($117,300)**		**($117,300)**
Total Federal Government Expenditures	**$429,302**	**$102,862**	**$530,164**
Total Federal Government Expenditures (1990 constant $)	***$491,267***	***$143,101***	***$634,368***

* Data source: CANMET project files.

CHAPTER 4

SPLIT SET SLING TRIALS

SUMMARY

SPLIT SET SLING TRIAL

Testing of new technology to stabilize the roofs and their supporting structures within underground coal mine gateroads.

Cost of Project (1987): $9.300

Cost to CANMET (1987): $5,000

Participants: CANMET (Cape Breton Coal Research Laboratory) and Cape Breton Development Corporation.

Status: The demonstration was executed in 1987. Results are transferrable to other underground mines with similar situations.

CANMET Roles: Assistance with the research and development of the trial techniques.

Benefits: The trial demonstrated a new technique for strengthening the roof structure of underground mining roadways; allowed production levels of $144K/day of extracted coal to be maintained, instead of $72K/day and less over time without the sling sets; avoided expenditures for redigging gateroads at a cost of $1000/metre; and increased safety for workers.

Other Features: Significant improvements in productivity, health and safety. Relatively low cost technology. Applicability depends on geological conditions.

SPLIT SET SLING TRIAL

1. BACKGROUND

In 1987, the Cape Breton Development Corporation experienced the deformation of the longwall gateroads at its Phalen Colliery mine. If unaddressed, there was the potential for excessive deterioration as the wallface was mined, possibly leading to safety problems and early closure of the mine.

Normally the gateroads leading to the wallface are five metres wide and three and a half metres high. Steel beams, one metre apart, support the sides and roof of the roadway. Instability problems were experienced at the ends of the gateroad. With deformation of the steel supports, the roof of the gateroad dropped, significantly reducing clearance. This resulted in difficulties in moving men and equipment to and along the wallface.

Besides the questions of safety, this situation also meant that projected rates for production dropped (from a target of two metres of wallface removed to only one and a half metres removed per shift), and costs increased significantly.

Initial research on the causes of the deformation focused on the quality of the support installation, and the interaction of the overlying workings and local lithology. Strong correlations were found between the geological structure of the roof and the problem areas when increased pressures were generated by the retreating wallface.

As this situation progressed, several experiments were conducted to remedy the instabilities. In one experiment, a series of four split set cable slings was installed.

Split set slings are composed of a 1/2" diameter straight wire cable that is installed across the roof of the mine roadway. The cable is anchored in cement-filled holes that are set at 45° angles over each rib side (See figure in Appendix A.) Gypsum-based cement cartridges are placed at the ends of the holes to provide permanent anchorage for the cables. As the second end of the cable is installed at the other side of the roadway roof, the tension is produced and the cable provides vertical support.

Observations suggested that the slings controlled further instability, and a larger scale trial was developed to more fully determine the value of this remedial technique.

The Trial

In 1987, with the assistance of CANMET personnel, the Cape Breton Development Corporation began a more extensive trial of the use of split set cable slings. Two sites were chosen for the trials. Each site had unstable roof conditions and enough room to permit installation of the slings.

Each site was divided into three sections, with each section being 20 metres long. The slings were installed only in the middle section of each site, allowing comparisons to immediate areas without similar reinforcement. Twenty slings were installed (one metre apart) in the centre sections of each site. (See Diagram 1.)

Monitoring of the trial included observations of three critical factors. The effectiveness of the split sets in providing support, the extent to which the roadway roof continued to collapse, and the impacts on wallface operations[1] were all monitored during the trial. Geotechnical instrumentation recorded cable tensions, the loading imposed on the steel supports and vertical closures of the gates. Photographs were taken at regular intervals to provide a visual record of the conditions.

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[1] Impacts on wallface operations that were monitored included records of wall retreat rate, tonnage and delays.

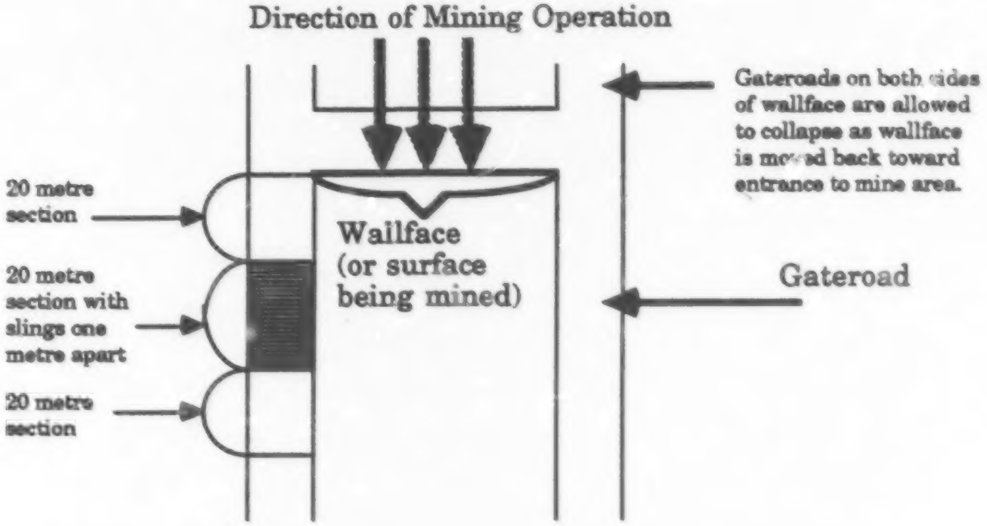
Direction of Mining Operation
Gateroads on both sides of wallface are allowed to collapse as wallface is moved back toward entrance to mine area.
20 metre section
20 metre section with slings one metre apart
20 metre section
Wallface (or surface being mined)
Gateroad

Diagram 1: Illustration of one of the sites for split set slings trials, viewed from the roof of the roadway.

2. ISSUES

This analysis has been primarily concerned with the extent to which non-measurable benefits (such as better health and safety conditions) have been realized, and the ways in which those benefits can be compared to the real costs incurred.

From all reports, the technology has been successful in restoring production levels, and stabilizing the roof structure of the gateroads. Costs incurred in the trial were small compared to other alternatives, and a variety of benefits was realized. The missing piece of information needed to identify the value of the trial, however, is the economic value of benefits realized. This indicator of overall value is addressed in the following analysis.

3. METHODOLOGY

In-depth interviews were conducted with CANMET program managers at the Cape Breton Coal Research Laboratory in Sydney, Nova Scotia and the manager responsible for this work at the Cape Breton Development Corporation.

In those discussions, we sought information on the technology used in the trial, the conditions for which the technology was used, the costs of the trial, perceived benefits of the trial, and their overall sense of value. Of particular importance was the collection of data related to the impact of the trial on overall production levels for the company. Supplementary reports of the trial were also reviewed. We also probed the financial implications of doing nothing to solve this deformation problem. Finally, we sought information about any resulting technology transfer to other mines.

4. FINDINGS

Since the benefits include lessened danger for miners, and given the difficulties of putting values on saved or lost lives, this analysis can not be handled as a strictly financial cost/benefit accounting. The discussion that follows will, however, describe the various costs and benefits associated with this project as fully as possible, and will include financial implications of the project where they are available.

Costs

COSTS = Σ {(Cost of Slings)
+ (Cost of Labour for Installation)
+ (Cost of Equipment)
+ (Cost of Research to develop trial techniques)
+ (Cost of Lost Production Time)
+ (Health and Safety Costs)}

Cost of Slings

During the trial 40 sling sets were used at a capital cost of approximately $65 each for a total of $2600.

Cost of Installation Labour

Two hours of labour were required for the installation of each set[1] at a cost of $40. Total labour costs for installing the 40 sling sets were, therefore, $1600.

The work crews assigned to the trial project would otherwise have been working on the cutting or recutting of roadways. Logically, their assignment to the trial work, therefore, involved a commensurate delay in their productive work on the roadways. Provided no new labour was hired to compensate them:

i) CBDC's production schedule was delayed, and
ii) there was no displacement, employment, or income effect.

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[1] Observations at the time of the trial indicated that an average of 53 minutes was required to install each sling set. This did not, however, include the time required to cut corrugated sheets and move struts. For this reason an average of 2 hours per sling set is used in this analysis.

Cost of Equipment

Equipment that was used for the trial consisted of a jackleg drill and tapered steel, and a driver tool for the split sets. Only the driver tool was not readily available among the equipment at the Cape Breton Development Corporation, and was supplied at a cost of $100.

Cost of Research

Research and learning time to develop the trial techniques was supplied primarily by the Cape Breton Coal Research Laboratory (CANMET) and is averaged at $500/day, or $5,000 over a 6 month period.

Cost of Lost Production Time

Production was already diminishing at the time that the trials were initiated. Time delays caused by installations and monitoring of the split set slings were more than offset by the restoration of full production levels.

Health and Safety Costs

Health, safety, and environmental impacts of the trial work were negligible, according to company sources.

SUMMARY OF TRIAL COSTS

Cost of Slings (40 sling sets x $65)	$2,600
Labour for Installation (40 x $40)	$1,600
Equipment	$100
Research to develop trial techniques	$5,000
Cost of Lost Production Time	—
Health and Safety Costs	negligible
TOTAL	**$9,300**

Benefits

BENEFITS = Σ {(Increased production levels)
+ (Maintenance of scheduled production)
+ (Reduced costs for cleaning and transporting coal)
+ (Improved and proper ventilation of mine)
+ (Avoided costs of redigging gateroads)
+ (Increased safety and confidence among workers)}.

Increased Production Levels

Prior to the installation of the sling sets, mining crews were able to remove one and a half metres of the wallface per shift. Shifts are 8 hours, and roughly 400 tonnes of coal are removed per metre at a value of $40 per tonne. As a result production levels were able to recover roughly $24K of coal per shift or $72K of coal per day prior to the slings being installed at this particular wallface.

Following the installation of the slings, access to the wallface was restored, enabling easy movement of men and equipment. As a result, production levels doubled to over three metres of wallface per shift, or over $144K value of coal per day.

Maintenance of Scheduled Production

The set sling trial enabled the mine to maintain scheduled production and to keep a full complement of staff employed.

While the trial did not result in production levels over those that were planned for the mine, it did allow those production levels, and the revenues they generated, to be realized. Without the trial, the only way of preserving the investment already made in developing the mine area, would have been to dig new gateroads to the wallface. Redigging would be a costly alternative, estimated at roughly $1000 per metre[1] excluding equipment and lost production time.

Reduced Costs for Cleaning and Transporting Coal

Other benefits were realized in that the coal being removed from the mine by conveyor was no longer mixed with other rock and stones that had fallen from the gateroad roof onto the conveyor. This reduced the cost of cleaning the coal or transporting it. No specific estimate of these benefits was available.

Improved Ventilation

Proper ventilation in the mine was maintained with the use of the sling sets, avoiding health and safety concerns.

Increased Safety and Confidence Among Workers

Lastly, the benefits of saved lives cannot be measured. While no one was killed or injured with the unstable conditions prior to the trial, the improved stability that resulted surely increased the safety for workers, helped to ensure that no lives would be lost, and increased the workers, confidence in and satisfaction with their work conditions.

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[1] Compared with approximately $100/metre for the sling sets, with limited down time.

Benefits Derived From Split Set Sling Trial

Increased production levels over levels before the trial.	>$150K/40m.
Reduced costs for cleaning and transporting coal, which no longer had large amounts of rock and stones from roof mixed with it.	positive
Maintenance of Scheduled Production.	positive
Improved and proper ventilation of the mine was maintained.	positive
Avoided costly ($1000/metre) redigging of gateroads by spending $100/metre for sling sets net gain $900/metre or for the area covered by the split set slings (2 sites x 20 metres x $900)	$36K/40 m.
Increased safety for workers, and increased confidence among workers.	positive
TOTAL financial returns	>$186K/40m.

CONCLUSIONS

The analysis of the split set sling trial and the potential of using the technology in other applications suggests that the benefits described above far outweigh the costs, even though many of the benefits cannot be measured in direct dollar terms.

The graph in Appendix B illustrates the consequences that have accrued since the installation of the slings. The graph shows what happens to production levels as the gateroads deteriorate. With intervention (installation of the split set slings at time (t-y)), the benefits appear as the difference in production value between full production and a deteriorating production level. Any continued production after the time the mine area would otherwise have been closed for safety reasons (at time t_1) is seen as a further positive benefit.

Benefit ranges can be developed for the alternative scenario that includes redrilling of gateroads, but it is apparent that the sling sets are a superior solution on all counts: lower cost/metre; less down time; lower risks.

Distribution of costs and benefits for the trial can be summarized as follows:

Participant	Costs (PV)@	Benefits
CANMET/ Govt. of Canada	$6K	indirect[1]
Cape Breton Dev. Corp.	$5K	$356K[2]
TOTALS	$11K	$356K

Net Present Value: >$345K for 40m.

Break-Even/Payback: less than one shift (8 hours) of production, even including more than 50% of costs allocated to R&D!

Estimated Rate of Return: very high.

@ Reported in 1990 constant dollars, and rounded to the nearest thousand (000).

[1] No direct returns. Some value in increased production, and extended mine life, especially compared the projected socio-economic costs of shutting down.

[2] Based on 40 metres only. A net savings of $36K compared to recutting the roadway for this distance, and $320K for increased productivity of $72K per day at 9m. per day.

This number could obviously be much higher if we include the demonstration effect and its extrapolation to the rest of the mine operations. An alternative calculation would be to attribute the full extension of the mine life to this innovation, an extension which would cause a further massive increase in payback, but which seems to attribute an extraordinarily large benefit to a relatively small innovation.

This project demonstrates an almost fantastic return for a relatively simple technology. **We are concerned that the benefits may have been significantly over-attributed and would caution use of these data without further confirmation.** If they do represent a realistic accounting, one must wonder why the technology has not been much more aggressively sold and adopted. The split set slings are a readily available technology, at relatively low cost, and have high value in this type of application. This case appears to be one where people will soon wonder why the research and demonstration project was even necessary.

There are currently seven active, below ground coal mines in Canada, all of which could potentially make use of this technology. These mines employ an estimated 1700 miners, whose employment, health and safety can be improved by the application of this tested technology, where comparable instability problems are encountered. Their costs will vary, depending on their existing equipment, research required, and density of split set slings required.

It is expected that further use of the split set slings in other mining operations will result in much the same benefits as were realized during the trial. The technology will enable mining operations to maintain or enhance their production schedules and revenue bases, maintain planned employment levels, and reduce the level of danger to the health and lives of the employees.

APPENDIX A

DIAGRAM OF INSTALLATION OF SPLIT SET SLINGS

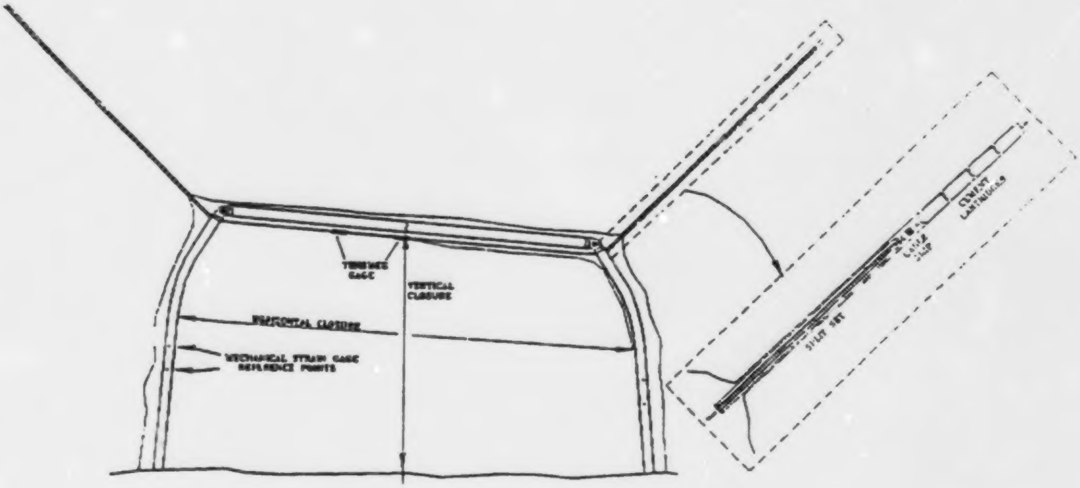
VERTICAL CLOSURE
HORIZONTAL CLOSURE
MECHANICAL STRAIN GAGE REFERENCE POINTS
SPLIT SET
CABLE CLIP
CEMENT CARTRIDGES

Figure 5 - Split set sling trial representative cross-section

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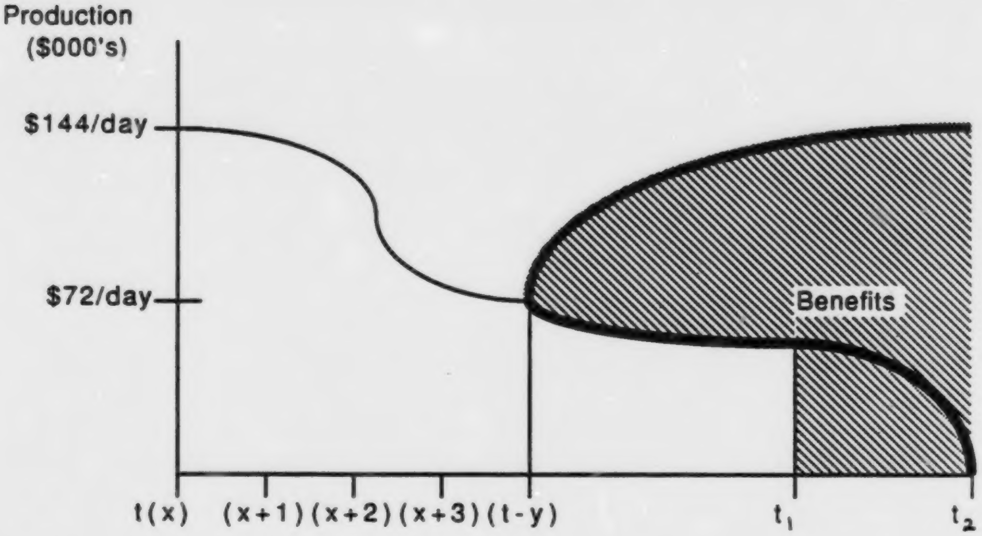
* From Cable Slings as Remedial Gateroad Support on Phalen 2 West Panel" paper by D.J. Forester, W.D. Gallant and S. Forgeron for presentation to Nova Scotia Mining Society, Sydney N.S. October 27, 1990.

APPENDIX B

EXTENT OF BENEFITS WITH INSTALLATION OF SLINGS



Notes:

▬ - without slings; declining values
▬ - with clings; restored values
(t-y) - point of intervention
t_1 - mine closed; production = $0/day
t_2 - expected mine life with slings at full production

* Graph prepared by Brystra Consultants, 1991,using data from project interviews "An Underground Trial of Cable Slings for Remedial Support of Longwall Gateroads," a paper presented to the 10th International Conference on Ground Control in Mining, by W. Gallant, R. Choquete, J. MacLachlan and S. Forgeron.

CHAPTER 5

GAMMA RAY DETECTION

SUMMARY

GAMMA RAY DETECTION

Research undertaken to develop the capability of measuring fluid dynamic phenomena in hydrocracking reactors operating at high temperatures and pressures, i.e., on the inside of thick-wall steel reactors.

Cost of Project: not applicable; was a capital project in mid-1980s. No current costs.

Cost to CANMET: not applicable. Total value invested nearing $1 million.

Participants: CANMET, AECL, Petro-Canada, (SNC/Lavalin Partec).

Status: Research and development for a 2-phase process has been successfully completed. The technology was applied in a hydrocracking demonstration unit and is now incorporated in the licensed technology package. No commercial applications of the technology are operating at the present time, due largely to low world prices for light crude feedstocks.

CANMET Roles: Provided funding for design and fabrication at AECL Laboratories; developed a pilot testing facility and carried out a pilot test; and worked with Petro-Canada on the larger demonstration of the techniques.

Benefits: Large potential benefits in terms of more efficient refining processes, export of technology, reduced demand for imported oil, and better utilization of Canadian heavy oil resources.

Other Features: Development in CANMET of recognized expertise in the design of gamma ray detection systems, and in the analysis of data produced from them. One version of technology was licensed to Petro-Canada for commercial development and sale as part of the CANMET hydrocracking technology package.

GAMMA RAY DETECTION

1. BACKGROUND

Use in CANMET Hydrocracking Technology

For light, sweet Middle East crudes, over 90% of the initial barrel can be converted into valuable light oils with normal atmospheric and vacuum processes, leaving only a 10% residual needing further treatment. For many heavy Canadian crudes, however, over 50% may remain as pitch after the atmospheric vacuum process.

In the refining industry, the conversion of heavy feedstocks (heavy oils, bitumen, atmospheric and vacuum bottoms) to light products (liquid petroleum gas, gas, light oils, kerosene) usually requires high temperature reactions at high pressures. CANMET has developed a comprehensive package of hydrocracking technology for this purpose.

Hydrocracking can effectively convert 90% of the residual pitch into more valuable lighter products, thus adding value and reducing disposal and environmental costs. Thus the value of hydrocracking is much higher for domestic crudes.

The technology involves the use of high pressure and temperature hydrogen reactors with thick (e.g., 12") steel walls. The gamma ray detection system which is the subject of this case study was developed as part of the control system for these reactors.

Gamma Ray Detection as a Control System

Since no direct access to the inside of the vessel is possible during the reaction, measurement of the reaction process inside the reactors has been an art form based on experience and judgement. As a result, the process was often operated inefficiently, producing less than the optimum product mix. Gamma ray detection techniques to measure fluid dynamic phenomena within thick-wall steel vessels were developed by CANMET using instruments developed for it by AECL's Chalk River Laboratories.[1] Gamma ray detection and analysis can now be used as part of an efficient control system for the process.

The gamma ray detection process involves directing a gamma ray through the vessel and its contents and measuring changes in the ray (or beam). The differences in the beam on the two sides of the vessels can be used to identify the condition of the contents of the vessel. For instance, the amount of solid, liquid or gas in the vessel can be identified at specific time points.

History of the Project

CANMET contracted with AECL to build its initial system from commercially available equipment. The design, size, and concept of the gamma ray scanner were determined jointly by a AECL-CANMET research team. The design and construction of this laboratory unit were carried out by AECL. Extensive R&D, including a 70 day pilot plant run, was carried out at CANMET to develop the knowledge required to measure the fluid dynamic phenomena in the pilot plant reactor. Results were obtained to allow reliable scale up from pilot plant to commercial size.

The gamma ray detection system was including in the technology package sold to Petro-Canada as the "CANMET hydrocracking technology." A demonstration hydrocracking plant was then built by Petro-Canada in Montréal, with the assistance of Lavalin Partec[2] engineers. Gamma ray densitometers were installed on the reactor, based on recommendations from CANMET's research team. These instruments provide the information necessary to achieve optimized process conditions. The plant was operated at 1/3 normal capacity over the course of three years, primarily for research and development purposes. The experience and data from that project have resulted in numerous modifications and improvements to the hydrocracking system.

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[1] To obtain specifications for CANMET's gamma ray scanner, AECL also did some R&D work on their air bubble column facility. AECL's participation was under contract with CANMET.

[2] Now SNC Partec.

SNC Partec has in turn been licensed by Petro-Canada as its engineering and marketing agent for this technology package.[3] Several additional projects are under consideration in which the CANMET expertise may be incorporated, but they have yet to reach commercial implementation. When packages of CANMET hydrocracking technology are sold, there will be a royalties paid to CANMET of over $1 million per plant, with the actual amount to be determined by the size of the plant installed.

CANMET has continued to develop its gamma ray technologies and expertise apart from the version incorporated in the hydrocracking package licensed to Petro-Canada. The research group has continued to seek additional applications for its knowledge.

2. ISSUES

To date, CANMET's hydrocracking technology has not been used commercially. During the course of this study, we tried to ascertain whether this situation is the result simply of the current timing of the work (e.g., commercial application just hasn't been tried yet), or whether other factors have limited its commercial viability to date. In short, we have tried to determine when potential benefits of the gamma ray system might be realized through sales of the CANMET hydrocracking package.

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[3] Through the form of a joint venture in which Partec carries the engineering and marketing responsibilities.

There are other possible applications of CANMET's gamma ray expertise. Since the group has continued to pursue those opportunities, a second part of this analysis is concerned with other those applications, their expected benefits, and the costs to realize them.

3. METHODOLOGY

Our study design for this project included in-depth interviews with the project manager and the CANMET researchers responsible for the work. Their reviews of previous drafts of this chapter have been very constructive, particularly in sorting out the gamma ray components from the larger hydrocracking package.

Personal interviews were conducted in Montréal and Calgary with the key Petro-Canada personnel responsible for the tests at their demonstration plant in Montréal. In each of these sets of interviews, data were sought on the nature of the technology being developed, the potential benefits and costs as realized in the trial, and the likelihood of implementing this technology commercially. Telephone interviews about the hydrocracking licensing package and its marketing prospects was also conducted with senior SNC Partec personnel in Calgary.

4. FINDINGS

Costs

The original research on the gamma ray detection process was funded by CANMET, and performed by AECL. Subsequent work was partially funded by CANMET and Petro-Canada. The costs to each party are identified below.

The Cost Function

$$\text{COSTS} = \Sigma \; \{ \text{(Federal Government Support for Research)} \\ + \text{(Federal Government Support for Installation and Testing)} \\ + \text{(Petro-Canada Capital Costs during Installation)} \\ + \text{(Petro-Canada Professional Time during Installation)} \\ + \text{(Petro-Canada Operating Expenses (inc. professional time)} \}.$$

Federal Government Support for Research

Between 1980 and 1984 costs to CANMET totalled $314K for this joint research, including $150K for the gamma ray scanner and related electronics.

Federal Government Support for Installation and Testing

In 1985, when CANMET was developing the pilot plant operation, EMR expenditures totalled $314K for capital costs, operating expenses and professional time. This sum includes 50% of pilot plant operating costs, attributed to the gamma ray development work.

Total CANMET/EMR contributions for this demonstration were, therefore, $628K.

Petro-Canada Capital Costs for Installation

The Petro-Canada demonstration plant required less than $0.5 million for capital expenses incurred during the installation.

Value of Petro-Canada Professional Time during Installation

During the installation phase, Petro-Canada contributed 1/2 PY (salary and benefits estimated at $65K) to the project.

Petro-Canada Operating Expenses

Three years of demonstrations of the adapted gamma ray technology required a total of four person-months (estimated at $43K).

Total Petro-Canada costs are, therefore, valued at a maximum of $608K.

The environmental costs of this research and technology development have been assessed as insignificant.

Summary of Costs Incurred
(current dollars)

	Capital	O&M	Total
By CANMET/EMR (1980-1985)	$150K	$478K	$628K
By Petro-Canada (1985-1988)	<$500K	$108K	<$608K
TOTALS	**<$650K**	**$586K**	**<$1,236K**
(1990 constant $)	**<$816K**	**$893K**	**<$1,709K**

Benefits

The gamma ray detection process has several different benefits. Most must be classified as indirect benefits since the direct economic benefits result from the hydrocracking process, not the gamma ray technique itself. However, in part because of the gamma ray measurements, the CANMET hydrocracking technology is now considered the best two-phase system in the world. Gamma ray detection has added significant value and has improved prospects for sales of CANMET hydrocracking technology when the market improves.

The Benefit Function

BENEFITS = Σ { (Value of Productivity Improvements)
+ (Value of Potential Royalties)
+ (Value of Other Potential Applications)
+ (Environmental Benefits) }.

Productivity

On a theoretical level, the development of the gamma ray detection technology has enabled the appropriate design of the hydrocracking unit and optimization of that process. It also provided the research team with a much better understanding of the fluid dynamic phenomena (gas holdups, flow regime) under high pressures and high temperature conditions. In addition, the gamma ray detection system can be used as part of the control and measurement system for operating hydrocrackers.

With the normal atmospheric and vacuum refining process, heavier crude oils usually produce a residual of about 35% per barrel. The heavy portion is even greater when heavier crudes are refined. With the hydrocracking process, the recovery of lighter ends rises drastically to over 90% of the residual pitch. Since lighter products sell at more than 1.5 times the price of heavy products, valuable gains can be achieved.

CANMET hydrocracking compares favorably with technologies developed elsewhere in the world, based on the most recent studies on heavy oil upgrading processes. A senior CANMET official has estimated that the CANMET technique is 10% to 15% cheaper than other techniques in terms of both capital and operating costs.

Value of Potential Royalties Associated with CANMET Hydrocracking

The value of the gamma ray detection technology, however, is dependent in large part on future sales of the hydrocracking technology. SNC Partec is continuing to seek markets for the CANMET hydrocracking system and has several current prospects. While no sales have yet occurred, that company remains optimistic that a breakthrough will happen.

A promising current prospect is with an Iranian oil company project for the hydrocracking of heavy crude oil. The plant size (10K bbls/day) would be twice that of the Petro-Canada demonstration plant in Montreal. If that project goes through, it could trigger other initiatives in other parts of the world where heavy crudes or oils could be advantageously upgraded, such as in Mexico or in South America.

CANMET benefits from sales of the hydrocracking technology would be through the payment of royalties. Those royalties are a fixed percentage of the deal, with variations due to the size of the installed plant. The smallest plant would likely result in a payment to CANMET of slightly over $1 million. The gamma ray portion of that amount is not defined, other than to indicate that it is an important, albeit small, part of the total costs. Partec and Petro-Canada participants have estimated the value attributable to the gamma ray work at 5% of CANMET's royalty, largely on the basis of its contribution to the refinement of the design. Installation of gamma ray systems on future plants is likely, but not necessarily part of the design.

Value of Other Applications

CANMET's capability in the measurement of fluid dynamic phenomena in high pressure/ high temperature hydro-reactors is rare. There are perhaps only two or three other places in the world which possess a similar R&D capability.

CANMET is presently discussing application of the gamma ray process with Syncrude and Husky. Each is expected to use gamma ray detection to control their three-phase fluidized bed reactors. While the technology will be similar to that developed for Petro-Canada for the two-phase CANMET hydrocracking process, new R&D will be required to adapt the gamma ray knowledge for three-phase reactors including heavy particulates.

Other applications of the technology include its use in the production of oil liquids from pitch and coal. The gamma ray detection technology would be used to measure gas hold-ups. A consortium (consisting of AOSTRA, Amoco, and Rheinbraun Co.) has recently been formed to address this type of co-processing application.

Environmental Benefits of Hydrocracking

While export sales of hydrocrackers would have a positive impact on our balance of trade, they would also have a positive impact on the environment. The hydrogen-to-carbon ratio improves with hydrocracking, yielding less carbon dioxide. Sulphur content is also reduced significantly.

As a whole, the hydrocracking treatment of heavy end products will remove a large portion of air pollutants, namely:

- sulphur	60-70%
- nitrogen	50%
- metals	99 %.

These contaminants can be reduced to ppm levels in downstream hydrocracking.

SUMMARY OF POTENTIAL BENEFITS

Productivity Improvements	positive value
Potential Royalties	> $50K/ HC plant
Other Potential Applications	positive value
Environmental Benefits	positive value

Other Findings

Impact of Oil Prices

As part of this analysis, we examined factors that have limited the use of this technology for commercial purposes. Current international prices of oil ($18-20/barrel) are too low to warrant the extraction of heavy oils in Canada and the development of hydrocracking facilities for their refinement. Prices closer to $30/barrel would be required to make this technology really attractive to refiners in Canada and elsewhere, and there appears to be little prospect of seeing $30 crude oil in the near future.

Technology Transfer and Licensing

Under the agreement with Petro-Canada, a gamma ray detection system was part of the whole hydrocracking technology licensed to Petro-Canada for commercialization. Any part of the technology that was developed prior to the agreement is owned by CANMET; that which was developed after the agreement is jointly owned by Petro-Canada and CANMET. CANMET owns the gamma ray know-how. CANMET has the opportunity to further develop the gamma ray technologies, and is doing so.

With the closing of the Montréal plant, Petro-Canada no longer had the facilities for using this technology itself. The effort to licence the technology to other refiners has slowed considerably under present world oil prices, but remains active.

5. CONCLUSIONS

The financial ratios in the Gamma Ray Detection project are summarized below. They are necessarily vague, since the benefits are still largely stated in a conditional future, dependent on the scope and conditions of future sales.

Participant	Costs (PV)@	Benefits (PV)@
CANMET/ Govt. of Canada	$955K	$0[4]
AECL	$0	some[5]
Petro-Canada	$754K	unknown[6]
TOTALS	$1,709K	small

Net Present Value: likely negative at this time. Project costs are now sunk. Returns could improve rapidly either through direct sales of CANMET expertise or as part of CANMET hydrocracking sales. Sales of hydrocracking services by Petro-Canada, via its Montréal refinery, might also be considered as a small indirect benefit of the gamma ray development work.

Break-Even/Payback: Approximately $1 million in royalties attributable to the gamma ray system, or to the competitive advantages it gives hydrocracking users, would be required to make this CANMET investment break even. The former is possible, although not very likely in the next five years, given current market conditions. The latter could be very difficult to

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@ Reported in 1990 constant dollars, and rounded to the nearest thousand (000).

[4] No direct returns as yet. Sales of the hydrocracking technology will result in a multimillion dollar royalty to CANMET. The amount attributable to the gamma ray process is suggested as 5%. The gamma ray system is estimated to be 0.1% of the total package cost, yet it is a critical part of the technology, significantly augmenting the economic productivity of the system. Its inclusion not only enhances the value of the system, but may make the critical difference in value which leads to sales over competing technologies. The attributable royalty share, however, is based on its contribution to the development of the overall technology design.

[5] AECL was paid in full by CANMET for its services in developing the gamma ray source device. We assume that AECL considers such work a net benefit, although no specific value has been assigned here.

[6] Limited value to date, although some improvements in production values will have occurred during the pilot plant operation. The real value will come with operation of the hydrocracking unit in Petro-Canada's own plants and with licensed sales of the larger hydrocracking technology, incorporating the Gamma Ray detection process. Those have yet to occur, although some return was felt to be imminent as of January 1992.

estimate, but would occur if either Petro-Canada uses its Montréal plant for hydrocracking services, or other Canadian producers use CANMET knowledge to upgrade their refineries. These are more likely, but our data were insufficient to estimate likely returns.

Estimated Rate of Return: Negative so far. Should be treated as a research investment at this point.

In general, the technical tests were successful. CANMET's hydrocracking technology has been proven effective, and economically practical at high crude oil prices. Present world oil supplies of light crudes and reduced crude prices have combined to make the hydrocracking technology uneconomic so far. In the last few months, the price gap between light and heavy oils has grown to the point where hydrocracking is becoming attractive again. There were press reports in January 1992, that Petro-Canada was reactivating its Montréal facility to process heavy foreign oils for re-export.

SNC Partec is continuing its efforts to sell the hydrocracking technology. The firm has had some difficulty with the demonstration plant closed. While the plant closure was based on other considerations than the process' viability, potential clients have wondered about the value of the process if the plant wasn't running. Reactivation of the plant should make that job easier.

The most critical factor, however, is the world price of oil and the spread between light and heavy grades. With light crudes under $20/bbl, there is a vastly reduced market for heavy crudes needing upgrading. Similarly, with depressed prices for light crudes, prices for lighter products are reduced, making the value of upgrading less. Under these circumstances, economic justifications for hydrocracking are minimal. Without a major price recovery, installed units would have to be justified on the basis of either national security of oil supplies or environmental qualities, both less convincing than an economic return.

CANMET has continued to market its expertise with the process and expects to develop systems for several plants, including HRI (Amoco) units in the US and Husky's bi-provincial upgrader in Lloydminster.

The gamma ray detection capability at CANMET has proven itself capable of making a substantial contribution to the competitiveness of major Canadian technologies. Until those technologies become widespread, it will remain largely an R&D service, rather than a revenue producer. As CANMET's technologies are installed in commercial applications, there is potential for substantial additional revenues through royalties and licences.

CHAPTER 6

CANSPECS

SUMMARY

CANSPECS

Program for blind round-robin testing of coal and petroleum coke samples by 124 testing laboratories to promote consistent testing methodologies and results, and to generate a greater understanding among analysts of the different qualities of various types of coal and petroleum coke. Operating since 1980.

Cost of Program: $145K/year since 1980.

Cost to CANMET: $50K/year (1980-1991).

Participants: 124 testing laboratories in Canada and other countries.

Status: Established program with recognition from international standards setting bodies.

CANMET Roles: Administration of program, analysis of results, and use of results to promote Canadian coals and international standards in Canadian interests.

Benefits: Increased confidence in testing procedures among labs, approximately $3 million in savings for one participating coal user.

Other Features: Reduced emissions for coal users, private sector participation, despite costs and largely intangible benefits for most participants. Export advantages are not yet apparent.

CANSPECS

1. BACKGROUND

International standards-setting bodies such as the American Society for Testing of Materials (ASTM) have defined the characteristics of different grades of coal, according to their:

- sulfur and ash contents,
- heating values,
- moisture content, and
- volatility.

During the late 1970s the Canadian government identified that most assessments of coal properties were primarily based on coals from the Appalachian area, and that those coals had significantly different values from Canadian coals. This condition had serious implications for the marketing of Canadian coal, as it was not seen by buyers to match the ideal characteristics of standard coal samples.

In 1980, CANMET began CANSPECS -- a round-robin blind testing program for the purpose of testing Canadian coal samples. A number of testing facilities across Canada and some international labs agreed to be part of this periodic testing process.

Three or four times per year CANMET sends samples of coal to the participating labs and requests that tests be undertaken for: moisture content, ash analysis, volatility, Btus/lb., and sulfur content. Labs need not undertake all of the tests requested by CANMET, but may select the particular tests that they are normally equipped to handle.

As part of the round-robin test, the participating labs are assigned a number. They are not told which other labs are participating, nor are they told the numbers of any other labs.

Once the tests have been performed, the results are returned to CANMET, where they are collated with the results of the other testing labs. Test results are reported by lab number only. Participants can compare their results and testing procedures with those of other labs. Identities, however, are protected.

CANMET uses the results in discussions with international standard-setting groups, to provide a greater awareness of the properties of other coal formations. CANMET also uses the data from these tests to assess whether existing standard test methods properly represent the beneficial characteristics of Canadian coals, and to evaluate proposed standards prior to their adoption, to ensure that they are consistent with Canadian interests.

CANSPECS is described as a pipeline for information sharing and quality assurance. There are currently 98 labs in 22 countries involved in the coal testing part of CANSPECS, including 36 Canadian and 62 foreign labs.

CANSPECS has recently been expanded from coal testing to also include the testing of petroleum coke. This new area of testing does not have the extensive network that exists for the coal testing -- 13 Canadian labs and 13 foreign participants are involved in the petroleum coke testing. This petroleum coke testing deals basically with a waste product, the physical properties of which CANMET would like to better understand.

A third area of testing is also being planned. It will address issues related to the properties of fly ash.

2. ISSUES

In this case, the issues have been focussed on identifying any direct costs and benefits attributable to the labs participating in the CANSPECS program. Questions of particular interest included:

- Have the participants in CANSPECS been involved in a worthwhile testing program? Have the benefits to the participants and Canada outweighed the costs?

- Has participation resulted in the labs being able to offer a wider range of services?

- Has participation resulted in any increase in demand for Canadian coal or petroleum coke?

- Has participation resulted in any increase in demand for testing services among the labs involved?

3. METHODOLOGY

Our approach started with an in-depth interview with the program manager of the CANSPECS program to address: the administrative parameters of the program, the objectives of the program, and CANMET's objectives and perceptions of the program. From a list of the participating labs, a random sample was selected for further interviews with lab managers.

The sample included 7 Canadian labs (five coal testing/2 coke testing), 5 U.S. labs (3 coal/2 coke), and 3 other international labs (all coal testing participants). Personal on-site interviews were conducted with each of the Canadian organizations; telephone conversations were held with the U.S. participants, and mailed survey questionnaires were directed to the other international organizations. In all of the Canadian and U.S. cases, the laboratory managers were pleased to discuss their participation; two of the three off-shore firms returned the questionnaire, with extensive responses.

While our original approach and methodology called for separate analysis of the coal and coke program elements, our interviews produced very similar results. The rationales of the labs for participation in the program, their costs, and their benefits were all similar regardless of whether they were involved in coal or coke testing. Variations that did occur among responses were the result of the size of the organization, and not the type of testing they were doing for CANSPECS. For these reasons, we have incorporated both sets of responses into one set of findings.

4. FINDINGS

Rationales for Participation

The first observation to arise from this review of CANSPECS is that all of the participants appear to be involved in the program for their own particular reasons. While everyone interviewed agreed that the program serves to increase confidence in their own in-house testing operations, the impact of that confidence is directly related to the main function of the organization in which the lab is located.

Several different types of labs are involved in CANSPECS. Participating labs include: government labs; testing labs for coal/coke buyers; testing labs for coal/coke suppliers; and independent, private testing labs.

Government and quasi-government research testing labs tend to treat the CANSPECS process as another part of their normal operations. Their primary benefit was that of providing internal quality assurance of testing procedures.

Labs associated with coal user organizations tend to view the process as one that is helping them to be more forceful in their buying negotiations. They have increased confidence allowing them to demand higher quality product, and thereby reduce their own operating costs.

Supplier organizations use the test results to have a better sense of their customers' own testing capabilities. By ensuring that their own testing procedures are accurate, they are able to ensure that shipments will not be returned for failing to meet specifications, and are able to question or offset any conflicting tests done by their clients.

Private research labs use the CANSPECS results for internal quality control, ensuring that their procedures are valid. Many also make note of their involvement with CANSPECS in marketing their services.

Based on type of organization, these same rationales were also discovered among the U.S. lab participants. The size of the organization may affect the level of work that the lab puts into the CANSPECS analysis (with larger labs involving more of their analysts in each test); however, the reasons for participating seem to consistently follow the above patterns.

Costs

The Cost Function

The costs for the CANSPECS program are incurred by CANMET and the numerous laboratories world-wide that undertake the testing. Specifically,

COSTS = Σ { (CANMET Administrative Costs)
+ (Participant Laboratories' Operating Expenses)
+ (Environmental costs) }.

CANMET Administrative Costs

CANMET currently employs 1/4 PY to send out the CANSPECS samples, collate and distribute the results, for a cost of roughly $50K per year (salary, overhead, and operating expenses). CANMET personnel use these data in ongoing discussions with ASTM and other agencies which set standards for coal and coke products.

Participant Laboratories' Expenses

Using Dept. of Supply and Services procedures to estimate costs to the labs, CANSPECS estimates that a total of roughly $0.5 million will be spent by all laboratories to perform three sets of analyses per year. Our finding, however, suggest that there is a very wide range in costs for the labs -- from $50 to $4,000 per lab per analysis. Most of the lab managers we interviewed, however, suggested that their costs were close to $250 per set of tests. Applying that average value to all 98 labs participating in the coal analysis, the total costs to the labs for their involvement in all three of the sets of tests is estimated at approximately $75K/year. Likewise, the 26 labs involved in the petroleum coke testing would have costs of about $20K for three sets of tests per year.

The costs for performing the tests within the labs are limited to labour costs. Reagent costs are negligible, and equipment usage is insignificant, compared to ongoing operations. In fact, many labs indicated that analysts were given the samples, along with other normal assignments, and without any indication that the CANSPECS samples were part of a round-robin test. Time to perform the tests appear to be fairly uniformly 2-4 hours over the course of 2-4 days, depending on how many analysts are assigned to the task, and which of the tests the labs opted to do.

Environmental Costs

Lastly, we have found no evidence of the CANSPECS program putting a greater demand on our natural resources, and thereby increasing environmental costs.

SUMMARY OF COSTS

CANMET Administrative Costs	$50K per year
Participant Laboratories' Expenses (total for both coal and coke labs)	$95K per year
Environmental Costs	nil
TOTAL COSTS	**$145K per year**

Benefits

The Benefit Function

Most of the benefits from the CANSPECS program are not easily quantified. The following factors must, however, all be considered as part of the program's benefits.

BENEFITS = Σ { (Increased Confidence and Quality Assurance for Labs)
+ (Increased Recognition of CANMET's Expertise)
+ (Savings on Operating Costs for Users of Coal and Coke)
+ (Environmental Benefits)
+ (Market Impacts for Canadian Coal and Coke Producers)
+ (Market Impacts for Canadian Service Providers) }.

Increased Confidence and Quality Assurance For Labs

Benefits of increased confidence in testing procedures and quality assurances, which were mentioned by all labs contacted, are very real, but are not measurable. For foreign labs, an increased sense of international comparisons and a greater awareness of the differences between ASTM and ISO analytical standards are benefits of CANSPECS that go beyond increased confidence and quality assurances.

Increased Recognition of CANMET Expertise

It is also not possible to quantify the impact of increased recognition that CANMET has received for its collected data and knowledge base on the characteristics of different international types of coal. ASTM has worked extensively with CANMET in recent years, acknowledging the value of the data collected through CANSPECS, and recognizing that not all coals have the same qualities as standard U.S. coals[1]. As the knowledge base on petroleum coke is expanded, it is expected that CANMET will gain further international recognition for its knowledge base on this product as well.

Savings on Operating Costs for Users

The research design for this assignment did not permit a comprehensive assessment of user benefits. We did, however, find one case where a coal user was able to demand coal of a consistent quality from its supplier, and has been able to document that when the specified quality is met, it is able to realize significant savings in its operations. In this particular case, for every 1% reduction of ash content in the purchased coal they are able to save $750K in the maintenance and repairs of one electricity generating unit, as well as reduce their demand for coal by approximately 2% of their annual consumption.[2]

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[1] Up until the time that CANSPECS was initiated, ASTM standards for ideal qualities of coal were based on U.S. coals. CANSPECS has provided conclusive evidence that coals from other (non-US) regions have different characteristics, and that international standards should reflect a wider range of coal characteristics.

Since the start of its participation in CANSPECS, this firm has had greater confidence in its on-line ash meter, and has been able to go back to its coal supplier to question the ash content of purchased coal every two months. Consequently they have realized a 2% drop in ash content on delivered coal. They estimate that savings for their two generating units will be on the order of $3 million/yr. for maintenance costs alone. Additional savings to the coal user on reduced purchase of coal (approximately $1 million) are, in this case, offset by reduced revenues to the dedicated coal supplier.

Environmental Benefits

Coal users can realize environmental benefits with participation in CANSPECS. By having increased confidence in their testing results, coal users can monitor fly ash content, insist on lower levels of fly ash in their shipments, and realize reduced emissions levels from the burning of the coal. At the same time they will also be requiring less coal and placing less demand on Canada's coal resources.

Market Impacts for Canadian Coal and Coke Producers

In our review of CANSPECS we did not undertake a comprehensive market analysis. We did ask laboratory managers if they were aware of any market impacts. None reported such knowledge. Further testing of market impacts would require a different methodology and different response groups.

Interviews with lab managers did not identify any evidence of increased domestic or international sales of Canadian coals, resulting either directly or indirectly from the testing program. Where supplier participants are shipping their coal outside Canada, they tend to be shipping to buyers requiring their particular type of coal. Any short-term increases in sales are felt to be the result of other economic variables, not from increased confidence in quality control.

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[2] Lower ash content means that the coal will burn more efficiently, thereby reducing the overall demand for coal.

Similarly we found no evidence from coal users that CANSPECS has stimulated a decrease in the imports of coal or coke into Canada. Coal users appear to be very dependent on particular types of coals, based on transportation costs, and qualities of the coal.

Market Impacts for Canadian Service Providers

Independent labs participating in CANSPECS have noted that they make reference to their involvement in CANSPECS when marketing their services. They have not, however, been able to determine whether or not sales of their services have increased as a result.

We have not found any evidence of increased services being provided by the labs as a result of their involvement in CANSPECS. Lab managers have been asked by CANSPECS to do the tests that they are normally equipped to handle in their day-to-day operations. Among the lab managers interviewed, we found no evidence of labs adding new testing procedures, beyond those that they already did at the time they started CANSPECS. The sample, however, was small.

SUMMARY OF BENEFITS

Increased Confidence and Quality Assurance	definite
Increased Recognition of CANMET Expertise	some*
Savings on Operating Costs for Coal Users	>$3 mil./yr. in one case
Environmental Benefits	significant
Market Impacts	minimal

5. CONCLUSIONS

The financial ratios for each of the participants are summarized below.

Participant	Costs (PV)@	Benefits (PV)@
CANMET/ Govt. of Canada	$47K/year	$0[3]
124 testing labs	$90K/year	some[4]
Coal Mines	nil[5]	some[6]
Coal Buyers	$0	$ millions[7]
TOTALS (1980 - present)	$1,500K	$ millions

Net Present Value: Unknown, but likely to be several million dollars. See footnote to buyers' benefits.

Break-Even/Payback: Unknown. Based on just one report, a utility has saved more in three years than the entire program cost.

Estimated Rate of Return: Likely well over 100%.

[@] Reported in 1990 constant dollars, and rounded to the nearest thousand (000).

[3] No direct returns. Export sales of Canadian coal were expected to result from this program, but we were not able to substantiate any such results to date.

[4] Some additional sales were likely through increased confidence, visibility, and accuracy, but no monetary values were known or reported by any of the participants.

[5] Value of the samples tested. May actually be borne by labs, but are minimal to either.

[6] Probably benefited from better knowledge of their product, thus allowing for more accurate sales promises and pricing to average or higher quality, rather than lowest quality. May also have lost something by not being paid full price for substandard deliveries (see next note).

[7] One utility reported a very high return through its improved ability to control source quality. It is likely that other users will also experience similar benefits.

This review of the CANSPECS program revealed that the participating labs are very satisfied with the exercise. They believe it is worthwhile, and that the resources they are contributing are well spent.

There is clear evidence that government costs are more than matched by industry. In fact, industry contributions likely average about $95K/year. This average is nearly double the $50K administrative expenses that CANMET provides. Industry's willingness to make such contributions for a program without, in most cases, tangible economic benefits is a clear sign that it is well run and valuable to the industry. Even where managers of a few of the testing labs have noted some drawbacks to the program's administrative procedures, CANSPECS' overall value remains strong.

Reported benefits are all internal to the participants' organizations. Our interviews were limited to the lab managers; marketing people from the same organizations may have been able to offer evidence of external benefits. Quality control and quality assurance were the two most prevalent benefits cited. In the larger labs, where more than one person would participate in the CANSPECS analyses, additional benefits were reported in terms of professional development and training.

Independent labs that participate in CANSPECS have been able to attract business, due to their involvement, although the value of such business is not known. Coal suppliers are able to confirm the quality of their shipments, and avoid returned shipments.

Tangible economic benefits have been realized by at least one participating coal user -- at least $3 million annually. We cannot extrapolate from the benefits realized by this coal user to the other coal users who participate in CANSPECS (roughly 1/4 of the participants), as we do not have sufficient data to identify the representativeness of this user's operations. However, this example is, by itself, a noteworthy savings that more than offsets the $750 average cost of participating for the lab, as well as the approximately $145K total annual costs for the whole CANSPECS program.

CHAPTER 7

REVEGETATION OF URANIUM MINE TAILINGS

SUMMARY

REVEGETATION OF URANIUM MINE TAILINGS

R&D 1971-1980 on ways to revegetate uranium mine tailings at Elliot Lake, Ont. Additional reclamation research has continued since 1980.

Cost of Program: $300K/year (1990 constant $) for research on revegetation between 1970 and 1980.

Cost to CANMET: $224K/year (1990 constant $) between 1970 and 1980.

Participants: CANMET and Rio Algom Ltd.

Status: Revegetation R&D completed in 1978; further reclamation R&D continues to control acidity of soil.

CANMET Roles: Research and financial support, research equipment, analytic support, later funding for acidity control through the MEND program.

Benefits: Over 400 acres of mine tailings revegetated, aesthetic benefits, dust control including control of radioactive dust particles, surface stabilization, improved understanding of how to control acid-generating waste of mine tailings so that sites can be decommissioned. Value not yet known.

Other Features: Stimulated >$18.5 million of further research on acid control; ground water monitoring; the impacts of uranium radiation; and the development of water covers for mine tailings.

REVEGETATION OF URANIUM MINE TAILINGS

1. BACKGROUND

During the early 1970s, Rio Algom Ltd. began to research ways of reclaiming pyritic uranium mine tailings at its mine site at Elliot Lake in northern Ontario. The growth of vegetation on the tailings was seen as the best way to stabilize and reclaim this land, given significant erosion and dust control problems. With the dust of the uranium mine tailings containing radioactive particles, dust control was seen to be particularly important.

Three grasses were planted in the mid-1970s, in order to identify any growth problems with particular types of grass plants, and to identify the growth potential of those grasses that require the least maintenance. A recipe for ground preparation, timing of planting, fertilization and seed mix was developed as a result of these tests.

CANMET worked with Rio Algom on the original revegetation research, through provision of research time and equipment in revegetation tests on 400 acres. CANMET assisted Rio Algom in research on the process of revegetation; but Rio Algom implemented the findings.

The revegetation experiments resulted in new knowledge about the process of improving aesthetics, dust control, surface stabilization, and the subsequent reduction of movement of radioactive particles in the air. A manual was produced, and is currently being sold by CANMET[1], so that other mining operations can apply the same techniques to mine tailings elsewhere.

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[1] Manual of Methods Used in the Revegetation of Reactive Sulphide Tailings Basins; November, 1989; $20.00 per copy from CANMET.

The revegetation experiments also demonstrated that acid leaching from the tailings into the ground and ground water remained a problem following revegetation. Considerable other research to address acidity issues has subsequently been undertaken. This follow-on research by CANMET and the mining companies is seen as an indirect benefit arising from the original revegetation work; other significant costs are also associated with this indirect benefit.

2. ISSUES

This CANMET project was justified primarily on environmental and aesthetic grounds. Direct economic benefits were not a primary motive. To the extent that quantifiable economic benefits have accrued from the research, they are fortuitous but not intended.

This analysis of the project, therefore, is primarily concerned with:

* the extent to which the investment of time and money has been offset by non-economic benefits .

With the benefit of hindsight, other issues include:

* the extent to which the original research has stimulated follow-on research, and
* the extent to which a critical mass of Canadian expertise has been developed in this area.

3. METHODOLOGY

Our data collection for this project involved a set of meetings and telephone conversations with the CANMET project managers in Ottawa and Elliot Lake. We were most interested in identifying the background surrounding this research effort, the costs, and the expected and perceived benefits. We also met with the research manager for Rio Algom in Elliot Lake to further understand the company's role in this research, and the benefits as perceived from the industrial side.

Since some of the follow-on reclamation research has been done with the help of the Ground Water Research Institute at the University of Waterloo, we also made contact with researchers at the Institute and officers at the Business Development Office at the University for further information on their perception of resulting benefits.

Each of the individuals contacted on this project was most helpful, although the long time perspective (20 years since the start of the revegetation work) generally meant that information available was based on individual recollections. Most of the respondents have been involved with the work for a prolonged period, and therefore were able to offer extensive information about the research efforts.

4. FINDINGS

For this research project we found that although the costs were usually quantifiable, the benefits were not easily measurable. We can identify what has been accomplished by means of the research, but the results do not have a clearly defined value for Canada, CANMET or the industrial participants.

Costs

The Cost Function

COSTS = Σ { (CANMET Labour Costs)
+ (CANMET Equipment Costs)
+ (Rio Algom Labour Costs)
+ (Rio Algom Overhead and Lab Space Costs)
+ (Environmental Costs)
+ (Health and Safety Costs) }.

CANMET Labour Costs

CANMET annually contributed the equivalent of one person year of time and expertise during the years between 1970 and 1974. An additional half-person year was added to the revegetation/reclamation work each year between 1975 and 1980. For the purpose of this analysis one person year of research time in 1970 was valued at $40K (salary and benefits). As a result, CANMET's total cost for labour on this research between 1970 and 1980 is calculated at $560K in current dollars or $1,505K in 1990 constant dollars.

CANMET Equipment Costs

Farm equipment was also provided by CANMET for the work. This equipment included growth chambers for lab analysis and soil testing. The equipment was valued at roughly $0.5 million in 1970 (or $1.93 M in 1990 constant $). The total costs for the equipment should not, however, be attributed to the revegetation research alone, as it has been used on other CANMET research, and is still maintained by CANMET in Elliot Lake. Given the ten year life of the revegetation research, and the twenty year life of some of the equipment, half of the value of the equipment has been assigned to this project. ($250K in 1970 current $; or $964K in 1990 constant $).

Rio Algom Labour Costs

Rio Algom annually contributed 0.5 person years of time to the project between 1970 and 1978, along with overhead and lab space for some of the work. Using the same assumptions as for CANMET labour, we have identified that Rio Algom's contribution to labour was roughly $180K during the nine years of its participation. (This represents $544K in 1990 constant $.)

Rio Algom Overhead and Lab Space Costs

Rio Algom's contribution to lab space was on the order of $90K in current dollars (1970-1978) and $272K in 1990 constant dollars.

Environmental Costs

The revegetation research was done with the expectation that it would help to control radioactive dust. There are no identifiable environmental costs or benefits associated with this research.

Health and Safety Costs

Health and safety costs are seen only in the limited exposure of researchers to the dust particles during research and test plantings. Risks associated with such exposure are uncertain as they are low level and long term in nature. Individuals who would have otherwise been involved in other research related to the mine site have probably not experienced any greater health or safety risk than they would have otherwise incurred.

SUMMARY OF COSTS
(current & 1990 constant $)

	current $	1990 $
CANMET Costs		
equipment	$250K	$964K
labour (1970-1980)	$560K	$1,505K
Rio Algom Costs		
labour (1970-1978)	$180K	$544K
overhead/lab space (1970-78)	$90K	$272K
Total Costs (1970-1980)	$1,080K	$3,284K
Average Annual Costs	$98K	$299K

Benefits

Given the long period of time that has elapsed since the original research was conducted, the benefits of this work are identified as either direct benefits (stemming directly from the original research) or follow-on benefits (involving other projects, based on the original revegetation research).

The Benefit Function

DIRECT BENEFITS = Σ { (Development of Seed Mixture Recipe and Manual)
+ (Revegetation of 400 Acres of Land)
+ (Improved Aesthetics of the Revegetated Land)
+ (Dust Control)
+ (Limitation of Airborne Disbursement of Radioactive Dust Particles)
+ (Control of Erosion and Surface Stabilization) }.

Development of Seed Mixture Recipe

The recipe of seeds for grasses that will grow on the mine tailings is felt to be appropriate for other uranium and metal mining tailings. The mixture is believed to be appropriate for all climates except very dry desert conditions. It is designed to stabilize surfaces for 2-3 years, until plants native to the region can begin to take over.

Revegetation and Improved Aesthetics

Approximately 400 acres were revegetated during this research. The aesthetics of the area were improved, however this was not a major objective as the site is 5-10 km. from the city limits of Elliot Lake, and 1 km. from a trailer park buffered by forest. The only roads into the area are logging roads, resulting in minimal public access to the area.

Dust Control and Limitation of Airborne Disbursement of Radioactive Dust Particles

The control of the dust from the tailings, however, was important for the population in the region, particularly for those working at the mine. Revegetation provided a solution to controlling dust, and limited the airborne disbursement of radioactive particles. While revegetation did not limit the presence of radioactive particles in the soil, or the acidity leaching from the tailings, it has reduced their airborne incursion into surface waters.

Erosion Control and Land Stabilization

With the establishment of a self-generating ground cover, erosion and surface stabilization problems were addressed.

SUMMARY OF DIRECT BENEFITS

Benefit	Value
Development of Seed Mixture Recipe	transferrable knowledge
Revegetation of Land	400 acres
Improved Aesthetics and Dust Control	positive
Stabilization of the Land	positive

Follow-On Benefits

Follow-on benefits stem from the project finding that revegetation did not significantly reduce the leaching of acid from the mine tailings and that this continued to be a problem. Joint industrial research on the acidity leaching issues consequently was initiated, including efforts at Rio Algom, INCO, the University of Guelph, Noranda, Cominco, and CANMET.

1. The first of these follow-on research efforts involved a team from CANMET, the University of Waterloo and Rio Algom. Between 1977 and 1985 the team looked at scenarios that could control acidity generation so that two particular sites could be closed out or decommissioned, thereby satisfying environmental regulations.

The University of Waterloo team included seven graduate students and two professors from the Ground Water Research Institute. Funding came from CANMET, Rio Algom, NSERC and NRC. Over $1 million was spent on the research labour, analytic costs, installation of monitoring equipment, and the actual monitoring. An additional $0.5 million was spent on capital expenses for research equipment.

Results included the development of scenarios for decommissioning two Rio Algom sites, with solutions that are generic to other acid generation sites. The two sites are now under regulatory review, prior to their actual decommissioning. Rio Algom estimates total costs for decommissioning two of their sites at $16 million, but that subsequent site closings by other mines can now be accomplished at much lower costs.

2. Technologies and equipment for ground water sampling and monitoring have been developed under contract by the University of Waterloo, and have been patented by CANMET. A model for monitoring ground water near uranium tailings is part of the results of this work. The model, which has been patented by CANMET, cost just over $3 million to develop. CANMET has put a price of $10K on the licensing and use of the model for private firms and $2-3K for institutional use. CANMET officials estimate that the market for it is probably limited to roughly 100 firms. To date, total revenues to CANMET for the licensing of this model have been less than $100K. From various assessments within CANMET, this model has value and will continue to generate licensing revenues, but it is not likely to generate a direct payback of the original investment.

3. In 1988, the Mine Environment Neutral Drainage (MEND) program was introduced by CANMET to fund research that would assist in the control of acid-generating waste from mine tailings. MEND is a five year program with a total budget of $12.5 million, supported by the Canadian mining industry, CANMET, Environment Canada, Indian and Northern Affairs Canada, and the governments of British Columbia, Manitoba, Ontario, Québec, and New Brunswick.

MEND is a long-term initiative to encourage and coordinate research on acidic drainage problems at mine sites. It is intended to reduce the environmental impact of closures of mine sites. By directly involving the mining industry in the work, technology transfer to end users is facilitated.

MEND projects are found all across Canada, including Manitoba, Quebec, Ontario, British Columbia, New Brunswick, the Yukon and the Northwest Territories. To date 34 projects have been initiated with 21 having been completed. Approximately $6 million had been spent through 1991.

International cooperation is a component of MEND, as the US Bureau of Mines and the Swedish Environmental Agency are also involved. Information and technology generated by MEND projects is freely available internationally.

4. A separate $3 million, three year study is just starting on the impacts of uranium radiation on the environment and people. This work is being funded by the Ontario Ministry of Northern Development and Mines, and is looking at how uranium neuclides move and affect groundwater, flora, and fauna and their impact on human consumption.

5. Rio Algom and CANMET are also currently undertaking a $5 million, three year study to develop a water cover for mine tailings. Of the $5 million, roughly $850K will be devoted to research, the balance to implementing of a flooding process that will meet regulatory requirements for decommissioning the site.

SUMMARY OF FOLLOW-ON RESEARCH
(objectives and costs (current $))

1. CANMET, Rio Algom, Univ. of Waterloo (1977-1985) Identification of scenarios for controlling acid generation from tailings	$ 1.5 M
2. CANMET, Univ. of Waterloo Development of technologies and equipment for ground water sampling and monitoring	$ 3 M
3. MEND Program (1988-1993) Research to assist in the control of acid-generating waste from mine tailings ($12.5 M total over 5 years)	$ 6 M to date
4. Ontario Min. of Northern Development and Mines (1991-1994) 3 year study on the impacts of uranium radiation	$ 3 M
5. Rio Algom and CANMET (1991-1994) 3 year study to develop a water cover for mine tailing	$ 5 M
TOTAL	**$18.5M**

The original research on revegetation clearly identified to CANMET and Rio Algom that further work on the control of acidic leaching was required if uranium mine tailings were to be stabilized. Considerable follow-on work has resulted from (and been based on) the original revegetation work. The dollar values for the follow-on efforts, however, are not included in our analysis of this project's costs and benefits for the following reasons.

Firstly, the costs associated with the further efforts to control acidic leachings were not part of the original scope of the revegetation work. They are therefore indirect or consequential costs, not direct costs of the original research.

Secondly, the total dollar value is not treated as a benefit of the earlier work (as had been suggested by some research participants). There are benefits that have come from the follow-on work, and those benefits would probably not have been realized without the earlier research efforts. However, to view the value (i.e., costs of $18.5M) of the follow-on research as a benefit of the earlier work would suggest that there were no costs associated with the follow-on research and that the original revegetation work had value (i.e., was successful) because of its ability to generate further, multi-million dollar expenditures on related research. By focusing instead on the benefits for Canada as a whole, the costs and value of these related projects and programs are most appropriately treated as indirect and consequential costs stemming from the earlier work. They have contributed greatly to our understanding of ways in which acidic leaching of mine tailings can be minimized. In this respect, the earlier work laid a solid foundation for valuable ongoing research on a better defined set of issues.

5. CONCLUSIONS

Costs and benefits are summarized as follows:

Participant	Costs (PV)@	Benefits (PV)@
CANMET/ Govt. of Canada	$2,469K	minimal[2]
Rio Algom Ltd.	$815K	growing[3]
Others	0	many[4]
TOTALS (1970-80))	$3,284K	growing

@ Reported in 1990 constant dollars, and rounded to the nearest thousand (000).

[2] No direct returns. Mainly in terms of mitigation of existing environmental problems.

[3] Through applications at other sites, and through avoidance of escalating environmental costs by early mitigation, and by development of technologies for early mitigation.

[4] Researchers have rapidly increased their funding in follow-on areas. Students have also had new opportunities created this way. Community residents have experienced reduced air-borne radioactivity and other environmental hazards. Other mining companies have been shown several effective mitigation measures to control environmental costs of tailings.

Net Present Value: Probably negative at this time. The project was supported as exploratory research and demonstration work, without expectation of direct economic returns.

Break-Even/Payback: Not applicable.

Estimated Rate of Return: Unknown, but fairly small in real dollars to date. As environmental concerns grow and clean-ups become more widely expected, the value of this work could soar. Recent estimates have placed the Elliot Lake clean-up in the $5 **billion** range. Given the mitigation measures developed on this work, and the specific direction it has provided for follow-up work, one could argue that its value is potentially enormous.

The research on revegetation of uranium mine tailings at Elliot Lake has met its original objectives of controlling the dust and erosion problems. The original work was not commissioned with quantifiable expected benefits and, indeed, most of the benefits remain non-quantifiable.

The costs for the original research work were approximately $1.08 million (or $3,284K in 1990 constant $), spread over an 11 year time period. This is less than $100K per year (ca. $300K in 1990$), of which CANMET contributed roughly 75%.

The benefits cannot be measured in the same terms.

From the original revegetation work, it is apparent that 400 acres were revegetated, and that a technology transfer package was developed to assist others in revegetating other sites. It is impossible to assign a value to dust control and the consequent reduction of radioactive particle dispersion in the area, improved aesthetics of the revegetated land, and surface stabilization. Extended benefits included: actual technology transfers through the dissemination of CANMET findings and reports; more effective targeting for subsequent research; and evidence that there was a larger problem which could be more clearly defined.

Considering that the original research was only 10% of the total (20 year) research budget to date, and that this first phase carried out the first stages of the research and helped to define the rest, then the initial expenditures should be considered as quite productive and effective for exploratory R&D.

There have been subsequent research expenditures of more than $18.5 million (1990 current dollars) to date. This follow-on research has provided greater understanding of ways in which uranium mine tailings can be covered and decommissioned in a more environmentally neutral way.

Follow-on research has become more complex and a better fit to address multi-faceted mine tailings issues. Research in the area is now dealing with a more focused range of the problems associated with the mine tailings, and is doing so in a more comprehensive and integrated manner.

Throughout this research, costs have been shared with industry, and continued industrial involvement in follow-on research has been observed. For some of the research, effective tripartite involvement, including the university sector, has also been experienced. University-based expertise in this area has been developed as a result of this work, providing in Canada a critical mass of specialists on reclamation options for mine tailings.[5]

Technology transfer benefits may be quite high, since there are many acidic tailings sites thought to be appropriate for this type of treatment. The MEND program managers have made research findings available, yet the impacts are unknown. Revenues from such disbursement of knowledge, documents, etc. are not recorded by the present distribution agency, the EMR library, in sufficient detail to attribute to this project. More broadly, implementation of the knowledge in industry is not monitored, so the social and industrial benefits cannot be determined. We found no evidence of any agency being responsible for monitoring or actively pursuing such benefits.

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[5] It has been noted, however, that university involvement in this research has been significantly less during the last ten years; with the result that few, if any graduate students have been able to receive funded training in this area recently. As a result, there has not been a continual stream of new researchers being trained, as there was in the early 1980s.

Since we still know relatively little about the long-term effects of low-level radiation, including air and water-borne particles, the damages solved by this work cannot yet be priced. The fact that follow-on research is an order of magnitude larger than the initial work, and that participation is growing, clearly indicates that the original work was significant and productive. While we can count most of the costs, the real benefits won't be known or measurable for many years. The professional consensus, however intangible, is that they will certainly be worthwhile.

CHAPTER 8

CERTIFICATION OF CONVEYOR BELTS

SUMMARY

CERTIFICATION OF CONVEYOR BELTS FOR USE IN UNDERGROUND MINING

CANMET certification program to test the strength and resistance to fire of materials used in conveyor belts for underground mines.

Cost of Program: $25-29K/year for CANMET, offset by revenues of $35K, largely from foreign manufacturers. Manufacturers' costs are estimated at ca. $150K(1990$).

Gain to CANMET: $10,000/year net before current depreciation charges of ca. $4K.

Participation: CANMET, CSA and producers of conveyor belts.

Status: Ongoing testing program to allow producers to meet CSA specifications for their products.

CANMET Roles: Performs tests, authorizes certifications.

Benefits: Ensures that CSA specifications are met; improves safety of mines; provides protection for mining companies when buying conveyor belts.

Other Features: Primarily foreign users; $200K testing facility recently replaced with $20K facility, eliminating toxic fumes and depreciation problems.

CERTIFICATION OF CONVEYOR BELTS FOR USE IN UNDERGROUND MINING

1. BACKGROUND

Certification of products used in underground mining in Canada goes back to 1957 when the first certificate was awarded by Energy Mines and Resources (on behalf of the federal government). In 1981, work was undertaken to upgrade and improve the specifications and move them to the Canadian Standards Association (CSA) so that they could be better enforced. CSA specifications were finalized in 1987, and have been in force since that time. To date, over 900 certificates have been awarded by EMR and CSA for products such as conveyor belts, ventilation materials and hydraulic fluids.

CANMET provides the testing facilities to determine the level at which products should be certified. Producers who wish to sell conveyor belting to underground coal mines in Canada, for example, are usually required by regulatory agencies to have their products certified by CANMET at the A1 or A2 level.[1] Once the manufacturers have their products certified, provincial inspectors ensure that the mines buy certified products.

Following the 1987 fire at the underground coal mine in Murdochville, Quebec, closer consideration was given to the fire-resistance of materials used in conveyor belts. The belt used in Murdochville caught fire and caused 53 miners to be trapped with one death. It had been purchased from a mine in Arizona and had not been tested prior to its installation at Murdochville.

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[1] CSA specifications, and CANMET testing of those specifications, affect Canadian and foreign companies that wish to sell products to Canadian mines. Canadian firms that sell to mines in the US or elsewhere must meet the specifications of those countries. US and UK specifications are very similar to the CSA specifications, allowing suppliers from the three countries to trade more easily among themselves.

In general, the inflammability of rubber belting is seen as a problem only in underground coal mines, where highly explosive coal dust must be taken into account. In most cases, these mines have been using plastic belting, which is more fire resistant. Rubber belting is more likely to go into hard rock mines (e.g., copper, iron ore, salt, etc.) where combustible dust is not as much of a problem.

Eighteen firms have received Canadian certification for their belting products. Roughly one third of these firms are producing plastic belting (all of them are foreign); the other two-thirds have rubber products. Only two Canadian firms are producing rubber belting for mine operations.[2] Thus, there is no domestic producer of belting for underground coal mines.

While the two Canadian manufacturers of conveyor belts do not produce belts for underground coal mines, they are still subject to certification of their products for other mining applications. Regulatory agencies or mine operators set a minimum level of belt certification with which all belts at a company site must comply. Manufacturers must have products that comply with these minimum certification levels to qualify as vendors to these companies. Besides the A1 and A2 levels (for underground coal mines), belts are tested for four other levels of performance.

The primary tests done for certification of the belting material are:

- a drum friction test, in which a sample is wrapped around a metal drum, and then rotated at very high speeds. Resistance to friction, as well as to breaking and tearing are tested in this way.

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[2] In addition to the two Canadian manufacturers of rubber belting, certified belting (both rubber and plastic) is currently available from companies in England, the United States, India, Japan, Korea and Australia.

- a small scale flame test in which a small sample is placed over a flame, in order to test for the speed at which the sample burns.
- a large burner (gallery) test, for which only CANMET has the necessary facilities. This test is much like the small scale flame test, but requires a full width section of the sample product.
- a static conductivity test, and
- an oxygen index test.

Some producers of belting materials may be able to do some of the testing for certification on their own premises, provided that a CANMET official or an approved, independent third party witnesses the testing. The new gallery testing for fire-resistance, however, can only be done by CANMET.

Manufacturers are responsible for producing and delivering the sample products to be tested. Samples may be 30 ft. long. Given the thickness and weight of the rubber belting, this may require delivery to the Ottawa test facility of a half ton shipment.

2. ISSUES

The certification of conveyor belts for underground mining is undertaken in order to ensure higher levels of safety for miners. Such certification is especially important for underground coal mines where coal dust is particularly flammable.

In general, plastic conveyor belts that are more resistant to fire have been installed in the underground coal mines, rather than rubber belts which are generally sold to above-ground mines and underground metal mining operations. A few exceptions where uncertified rubber belts have been used, and caught fire in underground coal mines, have illustrated the importance for mining safety of this certification process. The primary purpose of the CANMET service is, therefore, to ensure that conveyor belts used in mining operations pass the required tests, regardless of who has produced them, so that Canadian workers can be protected.

The principal issues that this study considers are:

- What is the level of costs expended in order to ensure this level of safety?
- What benefits result from CANMET's involvement in this certification process? and
- What impacts does this process have on the competitiveness of Canadian producers?

3. METHODOLOGY

The economic impact on Canada has been the focus of this analysis. Data collection has been concentrated primarily on the Canadian manufacturers of conveyor belts (who happen to be manufacturers of rubber belts). This approach was also pursued in part because of the importance that has been placed on the certification of rubber products since the Murdochville fire, despite the fact that neither Canadian firm sells its products to underground coal mines.

Intensive interviews were held with managers of the testing program at CANMET, and of the two Canadian firms that currently have certified products. We sought information on their costs, and the benefits they received from the service. Where appropriate, extrapolations of data for the foreign manufacturers of conveyor belts have been used.

4. FINDINGS

Costs

The Cost Function

COSTS = Σ { (Manufacturers' Costs of Producing Test Samples)
+ (Cost of Transporting Samples to Ottawa for Testing)
+ (Testing Fees)
+ (CSA Annual Inspections of Manufacturing Plants)
+ (CANMET Capital Costs for Testing Facility)
+ (CANMET Facility Maintenance Costs)
+ (CANMET Salaries for Performing Tests, Managing Certifications and Maintaining Databases) }.

Manufacturer's Costs of Producing Test Samples

Samples used in certification testing are produced from larger production runs. (Belts used in mining applications may be anywhere from 30 ft. to 30,000 ft. in length.) At a cost of $100/ft. for fabric-based belting, the 30 ft. of belting required for the CANMET certification tests will cost the firms about $3K to make.[3] Steel corded belts are more expensive to produce and will cost between $10K and $15K for the test samples. Transportation of samples to Ottawa may cost the Canadian firms another $1K per shipment. Foreign firms will have higher transportation costs.

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[3] These costs have probably been reduced somewhat with the switch from the large burner gallery to the smaller one, e.g., the fire testing used to require a sample 1.5x4m, where it now requires only 1.5x0.1m. Manufacturers' costs may not have shrunk much, however, since they must still set up their production lines to make any sample at all, even if CANMET needs less of it.

Testing Fees

If CANMET performs each of the five tests required for certification, a fee of nearly $2,300 is paid by the manufacturer to CANMET for performing this service. If more than one trial is necessary in the certification process, then CANMET's fees increase. In recent years, there have been fewer batches of tests, but larger numbers of samples in each batch. The average fee has also declined as more of the requirements focus on level C certification. Gross revenues to CANMET have remained fairly constant.

Certification is only required once for a given product. Therefore, these are relatively infrequent costs for the manufacturers. One of the Canadian producers has gone through the certification tests twice since 1987 (both times in 1988). The other one has a wider product range, but indicates that they have required certification of products about once a year.

CSA Annual Inspection of Manufacturing Plants

In order to ensure that their products are continuing to be manufactured in accordance with the originally certified specification, both of the Canadian manufacturers also face annual inspections of their plants by CSA officials. These inspections take up to half a day. A fee of $300 is charged for each inspection, and the companies must supply samples for testing during the visits. Total costs for each annual inspection have been estimated by the firms to be on the order of $1K. We have assumed similar costs are incurred by foreign manufacturers inspected by other agencies.

Total Costs to Manufacturers

When these various costs for manufacturers are taken into account, and given the frequency with which the Canadian manufacturers have used the service, their costs are estimated at ca. $24K per year. Annual costs to this international industry for these tests have been estimated at approximately

$150K per year. This cost estimate is based on the inclusion of only one steel-corded sample per year, as projected by the program manager.

CANMET Capital Costs for Testing Facility

In addition to the above costs, borne by the belting manufacturers, CANMET has also had costs in terms of running the testing services for the CSA standards.

As originally designed, the CANMET testing facility included a large burner gallery for determining the speed at which samples will burn. The facility was developed in 1984 at a cost of roughly $100K. Adjustments were made to try to ensure that the facility was not producing toxic emissions during the tests. Nearly $80K was spent in 1987 to install supplementary exhaust gas scrubbers, and in 1991 another $10K was expended for effluent treatment devices. The scrubbers catch smoke in a water spray, which leaves particles in barrels of water that require treatment. An additional $7K is projected for a wastewater treatment facility in fiscal 1992-93.

The large burner gallery has been decommissioned because the emission problems could not be solved satisfactorily. A smaller testing facility was developed that eliminated the problems with the large gallery. This smaller testing unit had a capital cost of roughly $10K.

Thus, ongoing operating costs should be charged only for depreciation on the smaller ($10K) gallery. The larger unit, with $100K of accumulated capital costs should be treated as a write-off for any undepreciated value. It is a large cost against program development, but should not be charged to ongoing operations. The accumulated capital cost of the scrubber system, at $97K in current dollars, should be largely written off. The facility remains in service, treating the products of the smaller gallery, but is probably not the optimal technology for the smaller burner.

CANMET Facility Maintenance Costs

Ongoing general maintenance for the CANMET larger burner testing facility was estimated at $5K per year; maintenance and operating costs for the smaller testing facility are estimated at $2K per year.

CANMET Salaries

Personnel costs required for testing the fire resistance of materials include 1/4 person year (PY) to perform the tests, and 1/20 PY to manage the certifications and maintain the data bases. Salary costs and benefits associated with these functions have been estimated at roughly $23K per year.

Total CANMET Costs

When these CANMET costs are added together, we find that total annual operating expenditures for this certification program are roughly $25K per year. These expenses have been offset by the testing fees paid by manufacturers. The approximate value of the revenues received by CANMET for this service since 1987 are estimated at $35K per year, for a net gain of about $10K per year.

Assuming that adjustments have been made to allow for the depreciated value of the large gallery burner facility and the scrubbers, then current annual costs to CANMET include $25K for personnel and maintenance, plus $2K per year for depreciation of the small burner gallery, and another $2K for the effluent treatment devices installed in 1991. With the write-off of the large gallery burner and scrubbers, it appears that CANMET is now actually realizing a net gain of $6K per year.

SUMMARY OF COSTS

MANUFACTURERS' COST COMPONENTS

Materials	$3-12K
CSA plant inspections (once per year)	$1K
Transportation of samples to Ottawa	$1K
CANMET testing fees	$2K

ESTIMATED COSTS TO MANUFACTURERS (1987-1991)

	current $	1990 constant $
Canadian Manufacturers	$115K	$120K
Costs to World-Wide Industry	$722K	$750K

CANMET ANNUAL COSTS (1991-)

	Approx. 1990 $
Personnel and Maintenance	$25K
Depreciation on 1991 Effluent system	$2K
Depreciation on Small Burner at 20%	$2K
Total Annual CANMET Costs	$29K
Less Approximate Annual Revenues received for CANMET tests *	($35K)
Net Annual (Gain) to CANMET	($6K)

DEPRECIATED CAPITAL EQUIPMENT

Large Burner Gallery	1984	$100K
Main Scrubber Facility	1987	$80K

* An average of less than 20% (or $7K/year) of CANMET's revenues for conveyor belt testing is derived from Canadian firms. The balance (more than $28K/year) represents foreign revenues.

Benefits

The Benefit Function

$$\text{BENEFITS} = \sum \{ (\text{Increased Safety for Underground Miners}) + (\text{CANMET Revenues from Certification Testing Fees}) + (\text{Increased International Profile for CANMET}) + (\text{Clearer Definition of Markets for Manufacturers}) \}.$$

Increased Safety for Underground Miners

The benefits of the CANMET/CSA program to test conveyor belts for strength and fire resistance are not easily quantifiable, as they are mostly related to increased safety conditions. The testing program, and the 1987 revisions, have ensured that the working conditions for underground miners are reasonably safe. The objective has been to try to prevent a re-occurrence of the Murdochville experience.

CANMET Revenues from Certification Testing Fees

CANMET has generated approximately $35K of revenues per year from the fees that it collects for this testing service. It is estimated that approximately 95% (or $33K) of these fees have been collected from foreign manufacturers.

Increased International Profile for CANMET

CANMET's international profile has been bolstered by this role as the Canadian authority on the safety of these mining supplies.

Clearer Definition of Markets for Manufacturers

For the Canadian manufacturers, the new certification program means a clearer sense of the markets where their products can be sold, which could, theoretically, help in selling those products. Both of the Canadian manufacturers, however, have indicated that while the new specifications now prevent their products from being sold to underground coal mines, that was not a market into which rubber conveyor belts had, as a rule, been previously sold. The Canadian manufacturers believe that the new CSA certification specifications are useful to the industry, but have not helped them to market their particular products.

The Murdochville fire was an unfortunate exception for the Canadian coal mines. Murdochville represents a case where the existence of standards did not stop a catastrophe. Hopefully the presence of more rigid standards will reduce the likelihood of similar problems in the future. It should be noted, however, that only knowledgeable and responsible management of the mining industry and enforcement of the standards will prevent similar problems.

5. CONCLUSIONS

Economic returns can be summarized as follows.

Participant	Costs (PV)@ 1987-91	Benefits (PV)@ 1987-91
CANMET/ Govt. of Canada	$384K	~$200K[4]
Canadian manufacturers	$120K[5]	unknown[6]
Foreign manufacturers	$630K[7]	unknown[8]
Mine operators/owners	minimal[9]	>0[10]
Miners, friends, etc.	0	health & safety
Canadian Standards Assn.	$3K	$3K[11]
TOTALS (1984-91) net of fees	~$1,137K	unknown

Net Present Value: Unknown.

@ Reported in 1990 constant dollars, and rounded to the nearest thousand (000).

[4] Based on fees received. Does not include fees for any testing done in 1984-87.

[5] Materials, shipping, and fees only. No labour costs included.

[6] Should be treated as marginal value of increased sales; neither firm released those data.

[7] Based on the report that only 9% of testing was for the two Canadian-based manufacturers (7 tests in five years; 15 tests at the facility every year).

[8] Should be treated as marginal value of increased sales; datum not available.

[9] Probably should include the costs of the regulation-enforced testing and certification process, which manufacturers would incorporate in their prices and pass on to the mine operators. (Likely also, therefore, to be passed on, if possible in higher commodity prices, but not where they are set by world markets. In the latter case, the costs will be reflected in reduced profitability for mine operations. These sums are unlikely to be sufficient by themselves to affect levels of production in either the short or long term, but may contribute to a pattern of higher cost mineral development.)

[10] Alternatively, this could also be treated as an insurance value against catastrophic costs of fire, and costs of paying for higher risk work sites. No values were available for those benefits, nor is there any known simple method to calculate their incidence in Canadian mining.

[11] The CSA conducts two plant inspections a year as a result of this program, resulting in a fee of $300 per inspection. CSA must also pay costs of nearly that amount to support its inspectors.

Break-Even/Payback: Unknown. Likely to be a very long time if annual operating surpluses are required to retire all of CANMET's capital investments.

Estimated Rate of Return: Not applicable. Annual gain to CANMET appears to be $6K on costs of ca. $30K, including depreciation on present equipment.

Canadian manufacturers have spent between $10K and $46K per year since 1987 to have their rubber conveyor belt products certified. The range in costs is based on the differences in production costs for the different types of rubber belt samples involved and the number of products tested each year. The total cost during this five year period is estimated at $120K (1990$), for an annual average of $24K.

While rubber belts are generally excluded from consideration for A1 and A2 levels, the Canadian manufacturers are still supportive of the new levels. They want to try to get higher B level ratings, for the higher their certification levels, the wider the markets into which their products can be sold.

CANMET costs to run the service have been roughly $25K per year, with about $35K of revenues received as fees for the testing services. The net gain to CANMET is, therefore, seen to be approximately $10K per year. This assumes that the initial capital costs are fully depreciated and written-off.[12]

Benefits, on the other hand, include: a smaller likelihood of rubber belts being used in underground coal mines, thereby increasing safety for miners; approximately $150K of foreign sales per year; and increased international recognition of CANMET's expertise and authority with regard to mining supply standards, among suppliers of mining equipment.

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[12] The initial $100K expenditure for the development of the large gallery burner test facility has already been fully depreciated (at the rate of 20% per year), and the 1987 expenditure of $80K for scrubbers will be fully depreciated by mid-1992.

From a strictly economic point of view, the benefit-cost factor is now positive. Safety benefits and increased international recognition of Canadian expertise further justify the operation. Adaptation of the original equipment to meet environmental standards has, however, been quite expensive, with nearly $200K of capital expenditures. While those costs have been expensed in previous years, and should now be considered fully depreciated, current annual surpluses would not be adequate to recover them.

CHAPTER 9

CANMET INVOLVEMENT WITH INTERNATIONAL STANDARD SETTING ORGANIZATIONS

SUMMARY

CANMET INVOLVEMENT WITH INTERNATIONAL STANDARD SETTING GROUPS

Expert participation on committees and sub-committees; quasi-regulatory activities.

Cost to CANMET: over $1 million per year (based on 1.5% of operating & salaries costs for CANMET for FY1990-91).

Participants: CANMET officials, international standard setting organizations, and industry.

Status: Ongoing activities within several organizations.

CANMET Roles: Representing Canada; coordinating Canadian policy; provision of technical expertise.

Benefits: Collecting international knowledge and contacts for Canada; assisting in the setting of international standards for the advantage of Canadian industry; avoiding disadvantages for Canadian industry in terms of international standards.

Other Features: Professional development experiences for CANMET staff. Realization of industrial benefits could be enhanced.

CANMET INVOLVEMENT WITH INTERNATIONAL STANDARD SETTING GROUPS

1. BACKGROUND

Standards are developed for a wide range of products and procedures in order to:

- protect the public from recognized hazards;
- specify levels of quality for materials, products and services; and
- ensure that finished products will work together and be interchangeable.

In some industries, the acceptance of standards is voluntary; in others, standards are regulated and made legally binding by government actions. Some industrial standards are developed unilaterally by a single agency or body, while others are developed through a consensus of all participants. Generally, standards developed with strong collaboration and input from a wide range of experts are found to be the most technically sound and credible. They are most likely to accomplish their objectives.

In Canada, the Standards Council of Canada (SCC) is the national coordinating agency for standardization. SCC is a crown corporation reporting to the Minister of Consumer and Corporate Affairs. The Council has created a National Standards System (NSS) which coordinates the work of five recognized standards-writing organizations,[1] five recognized certification organizations[2] and a large number of accredited testing organizations. The Council is charged with providing criteria for the development of national standards, providing criteria for other organizations within the NSS, providing audit programs, and supporting consumer and third-party input to standards development.

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[1] The Bureau de normalization du Québec (BNQ), the Canadian Gas Association (CGA), the Canadian General Standards Board (CGSB), the Canadian Standards Association (CSA) and Underwriters Laboratories of Canada (ULC).

Canadian standards are often based on internationally accepted standards, so that manufacturers have greater opportunities to sell their products to other countries without the need for product adaptations. In order to ensure that Canadian standards are compatible with international standards, the Standards Council participates on various committees of the International Organization of Standardization (ISO) and the International Electrotechnical Commission (IEC), including a few joint ISO-IEC committees. This work is particularly important at this time, as the European Community is relying heavily on the ISO and the IEC to develop European standards.

In addition, the Standards Council of Canada also operates the GATT Enquiry Point for External Affairs, provides a national advisory service on international standards, and promotes standardization through an educational program.

Some of the standards used in Canada are not ones that have been written and adopted by the SSC; rather they are standards of the American Society for Testing of Materials (ASTM). This group works with other standard setting groups in the U.S. and internationally.

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[2] The Canadian Standards Association (CSA) which certifies consumer and commercial products for performance and safety; the Canadian Gas Association (CGA) which writes standards for and certifies gas-fuelled products; the Underwriters Laboratory of Canada (ULC) which certifies products related to life, fire and property hazards; Warnock Hersey Professional Services which certifies fire resistant construction materials; and the Council of Forest Industries (COFI) which certifies plywood made from soft wood.

In some industrial areas, standards are established by associations or industry groups, rather than national standards setting (NSS) groups. In these cases, industrial associations will work with experts from all sectors to write their standards. They may then seek regulations that require the adoption of those standards, or may leave them as voluntary standards.

The different branches of CANMET have, over the years, worked extensively with the Standards Council of Canada, the American Society for Testing of Materials, and independent organizations that develop standards for energy- and mining-related industries. Participation on ISO and IEC committees is done as representatives of, or technical experts for, the Standards Council.

In May 1990, a CANMET report identified a very wide range of standards-related activities in which the five technical branches of CANMET were involved. (See Appendix A for list.) These activities involved many members of the staff, and cumulatively accounted for about 10 CANMET PYs (or 1.5% of the total staff). For some individuals, the amount of time spent on standards activities may be as high as 50%; for others, it may be as little as 10% or even less.

2. ISSUES

Due to the numerous groups involved in standards setting, certification, and testing, it has been difficult for CANMET to assemble current information on those activities, their costs and benefits. Attempts have been made in the past on an interdepartmental basis to reorganize the role of the Standards Council of Canada and the National Standards System, but have not met with agreement.[3] Some branches of CANMET have documented the extent of their activities with one or more of the standard setting organizations, but comprehensive data on activities with all organizations, across all branches has not been developed or maintained.

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[3] A task force was headed by Industry, Science and Technology in the late 1980s to develop a "Standards Policy for the 1990s" for Cabinet consideration. The report was not well

Among CANMET officials, there is widespread support for both the government's and CANMET's involvement in standards setting activities. CANMET is seen as an agency that can provide unbiased technical expertise, which will aid in the development of well formulated standards. Such standards, in turn, will facilitate domestic and international trade, encourage greater understanding of technology, and assist in the protection of the public's health and safety.

One issue that remains, however, is "What level of CANMET activity is warranted?" As they examine the scope of current CANMET activity, and some of the benefits that have accrued from it, decision-makers will more accurately assess the merits of future standards setting activities, and understand the conditions under which it is justified.[4] Another part of this issue is: Are the expected industrial benefits of this activity being delivered to Canadian industry?

Thirdly, international standard setting activity is a minor component of the work of most of the personnel participating in it, and therefore resembles a "low dosage effect" from a management point of view. This situation raises issues of focus, control, and cost effectiveness. Can CANMET provide adequate focus for an activity which is widely dispersed among many participants, none of whom is fully responsible for the function, nor spends the majority of his or her time on it?

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received by the departments involved, and no recommendations on Standards Policy were made to Cabinet.

[4] This is also the subject of a related report being prepared by the Research Program Office of CANMET.

3. METHODOLOGY

In order to better understand CANMET's activities regarding standards setting, we talked with four officials at CANMET who are directly involved in standards setting work. In-depth interviews were also conducted with representatives of the Standards Council of Canada. Additional data in the form of CANMET internal reports on standards setting activities was collected and analyzed.

4. FINDINGS

Costs

The Cost Function

$$\text{COSTS} = \Sigma\ \{(\text{CANMET Staff Time}) + (\text{CANMET Travel Costs})\}.$$

CANMET Staff Time

CANMET has identified that in 1989 approximately 10 person years of time were dedicated to standards-related work.[5] This represented 1.5% of the total CANMET staff time, or approximately $1 million in FY1990-91[6].

Our assessment of these figures suggests that this may be a low figure as the Efficiency and Alternative Energy Technology Branch (EAETB) has indicated that 0.5 PY is dedicated to standards work on 99 different committees or organizations (or < 1.0 day per committee per year). Where other branches have indicated that one PY covers about 11 or 12 committees, the EAETB time spent on standards work may in fact be as high as 9 PYs, moving the total CANMET allocation to 18.5 PYs. This higher figure would be the equivalent of 2.8% of the total CANMET staff time, or at least $2 million in FY 1990-91. Most of the people involved in international standards setting work, especially those staff members providing expert advice to international organizations, will command above average salaries. The values cited above are therefore interpreted as minimum costs.

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[5] "Standards: An Overview with a CANMET Focus," Research Policy Office, CANMET, May 30, 1990. The total of 10 PYs is distributed among the branches as 4 PYs to ERL, 2.2 PYs to MSL, 2 PYs to MRL, 1.5 PYs for MTL, and 0.5 PY to EAETB.

[6] This figure is based on CANMET budget figures for FY1990-91, which include operating and salary costs, with benefits added in, but the cost of contracts subtracted out.

CANMET Travel Costs

In addition to actual staff time, CANMET incurs some travel costs for its scientists to attend committee meetings, at which Canadian and international standards are discussed. Some travel costs to ISO and IEC meetings are paid for by the Standards Council, with CANMET donating the professional time (which is included in the above calculations). Other travel costs are not covered by the Standards Council. The Energy Research Laboratories estimate that at least $70K was spent on travel related to standards setting activities in FY 89/90.

The Mineral Sciences Laboratories (MSL) also provided evidence of $15K being spent per year for travel related to just ISO committees. If ISO work represents 77% of MSL's standards-related work, then it is reasonable to add another $3.5K to MSL's travel costs.

Other branches of CANMET have not been able to supply data on travel costs pertaining to standards setting activities. If, however, we assume that travel costs per PY will be fairly constant across branches then a range of $134K-$252K in CANMET travel costs for standards setting work would be reasonable.

SUMMARY OF ANNUAL COSTS

CANMET Salaries (10-18.5PY)*	up to $2,128K
CANMET approximate travel costs**	up to $252K

* These salary values are based on average CANMET salary and operations costs for FY 1990-91. Due to the fact that the PYs involved in international standard setting are generally higher priced PYs, these average values are interpreted as minimum values.

** proportional calculation, based on knowledge that 6.6 PYs have had allocations of roughly $89K/year for travel related to standards setting, and that PY allocations for this work are between 10 and 18.5 PYs per year.

Benefits

The functions that CANMET officials perform with regard to the different standard setting organizations are quite varied.

In general most the these CANMET activities focus on the following:

- Coordination and provision of, and expertise for technical committee activities;
- Provision of technical expertise directly to international standard setting bodies;
- Contributions to a pool of expertise for industry on matters related to international standardization;
- Collection and definition of reference materials to be used as standards for industrial comparisons;

- Serving as an unbiased referee on matters of contractual and regulatory specifications;

- Establishment of criteria for certification of equipment;

- Coordination of nationally and internationally based sample exchange programs to identify weak or beneficial standards technology;

- Helping industry remain competitive in national and international markets through the transfer of knowledge and skills;

- Aiding the improvement of quality assurance, facilities and expertise within Canadian industry, and

- Responding to pressures from international standard setting bodies to develop uniform international standards, and ensuring that international standards do not have a negative impact on Canadian industry.

The benefits derived from these activities are equally diverse Any of these activities can have significant benefits for Canadian industry.

The Benefit Function

BENEFITS = Σ { (Improved Health and Safety for Canadians)
+ (Reduced Energy Consumption)
+ (Increased International Recognition of Canadian Expertise)
+ (Improved Quality Assurance, Facilities and Expertise within Canadian Industry)
+ (Ensuring Access of Canadian Products to International Markets)
+ (Ensuring that Canadian Industry Does Not Face Unfair International Standards) }.

None of these benefits can be fully measured. Any of the CANMET international standard setting activities could result in one or more of these benefits over the course of several years.

For example, each of the above types of benefits has been realized through the CANSPECS program which was reviewed in another part of this study. CANSPECS is an example of an international sample exchange program that has helped CANMET become known as a source of expertise on specifications of different types of coal. CANMET has been able to use the data collected to ensure that international standards are no longer based on one type of coal, but instead recognize the composition of different coal formations.

Participants in that round-robin exchange/testing program have gained significant confidence in their own testing capabilities. One participant (a coal user) has been able to document savings to date of about $3 million/year on maintenance costs due to its ability to insist that specifications on coal shipments be met.

Work on standards has served the Canadian public and industry in other non-quantifiable ways as well. Just a few examples include the establishment of: standards on indoor air quality, controls of diesel exhaust in mine environments, controls of flammable products used in underground coal mines, efficiency improvements to residential heating systems, and specifications for safety equipment used in various occupations. In each of these areas, health and safety factors along with a reduced demand on energy fuels have been prime considerations. These are often long-term and non-quantifiable benefits.

5. CONCLUSIONS

Costs and benefits are summarized as follows:

Participant	Costs (PV)@	Benefits (PV)@
CANMET/ Govt. of Canada	~$2 million/year	unquantified[7]
TOTALS	~$2 million/year	unknown

Net Present Value: Undefined but positive.
Break-Even/Payback: Not relevant.
Estimated Rate of Return: Undefined but positive.

Some of the justifications for participating in international standard setting organizations and activities are based on economic benefits which could be determined. None appear to have been traced or recorded, suggesting that delivery of those expected benefits may also fall short of expectations. (In fact, we were surprised that the level of activity was known well enough to be reported.) Productivity of such tracing may be doubtful. The present system appears to enjoy wide confidence that it is effective and parsimonious.

One area where increased leverage might well be gained is in the transfer to Canadian enterprises of technical knowledge gained from these international activities. The intelligence function does not seem to be complete, by virtue of limited redistribution of information once it is collected, and thus does contribute its full value to the economy. Making use of this potential will, however, likely require additional resources.

@ Reported in 1990 constant dollars, and rounded to the nearest thousand (000).

[7] Largely framed in terms of effective participation and general benefits to Canada, but there are no hard data available with which to estimate actual economic benefits.

APPENDIX A

LIST OF CANMET INTERNATIONAL STANDARD SETTING ACTIVITIES

EATB

- Environment Canada (2 Committees)
- Canadian General Standards Board (14 Committees)
- Canadian Standards Association (34 Committees)
- International Energy Agency (15 Committees)
- Canadian Gas Association (6 Committees)
- International Organization for Standardization
- Standards Council of Canada (4 Committees)
- Canadian Pulp and Paper Association (3 Committees)
- Canadian Electrical Association (4 Committees)
- Canadian Committee on Electrotechnologies (4 Committees)
- Propane Gas Association of Canada (2 Committees)
- Canadian Home Builders Association
- Solar Energy Society of Canada
- Hydrogen Industry Council (2 Committees)
- Interdepart. ad hoc committee on emissions, safety & health effects of alternative fuels
- CANMET library committee
- International Photovoltaic Energy Project
- Atlantic Wind Test Board of Directors
- Interdepartmental Committee on Insulation

MTL

- International Organization for Standardization (2 Committees)
- International Institute of Welding (2 Committees)
- ASM International
- ASTM (3 Committees)
- National Association of Corrosion Engineers (6 Committees)
- CGSB (2 Committees)

MSL

- International Organization for Standardization
- Standards Council of Canada
- ASTM

MRL

- Canadian Standards Association (Several Committees)
- Canadian Gas Association (2 Committees)
- International Electrotechnical Commission (3 Committees)
- Standards Council of Canada
- United Nations Group of Experts on Explosives
- ASTM
- Radon/Thoron test labs in USA, EEC and Australia

ERL

- International Organization for Standardization (7 Committees)
- American Society of Mechanical Engineers (3 Committees)
- Wood Heating Alliance (2 Committees)
- ASTM (14 Committees)
- Canadian General Standards Board (7 Committees)
- Canadian Gas Association (4 Committees)
- Canadian Standards Association (14 Committees)

CHAPTER 10

IMAGE ANALYSIS

SUMMARY

IMAGE ANALYSIS

Technical advisory service, providing identification of minerals, mineral quantities and concentrations through electron microscope imaging. Part of CANMET's services and knowledge base in process mineralogy.

Cost of Program: $200K/year.

Cost to CANMET: Net operating profit of $50K/ year, not counting depreciation on capital equipment.

Participants: CANMET (Mineral Sciences Laboratories) and mining companies.

Status: Ongoing, technology and services being upgraded gradually as part of other on-going activities.

CANMET Role: Analysis on a fee-for-service basis.

Benefits: Better appreciation of characteristics of complex ores, leading to more appropriate technologies for recovery; higher recovery rates.

Other Features: High level of expertise established at CANMET; recognized by industry.

IMAGE ANALYSIS

1. BACKGROUND

Until 1965, the identification of the physical properties of minerals was accomplished by means of physical inspection, and mineral quantities were determined by point counting under a microscope. With the advance of electronic microscopes, identification began to be done electronically, and by 1969 differentiation of mineral quantities could be determined by image analysis using an optical microscope as an imaging instrument, but the minerals could not be identified automatically.

During the period 1976-1982, CSIRO in Australia developed image analysis techniques to identify the minerals, determine mineral quantities and determine mineral liberations. In 1983 CANMET purchased similar off-the-shelf equipment and integrated it into a system that had greater capabilities than the Australian equipment at that time. By 1985, the CANMET system was fully programmed. It has been operational since.

Today, CANMET is one of only two labs in Canada to have this type of equipment. (The other is at the New Brunswick Research and Productivity Council.) Both are used on a fee-for-service basis, providing imaging analyses to the mining industry.[1]

CANMET has been involved in image analysis since the mid-1970s. Early equipment was limited in capability and efficiency, however, and the decision was made to purchase state-of-the-art equipment in the early 1980s. Using funding from the Short-Term Assistance in Research and

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[1] Under the recent Mineral Deposits Agreement with Manitoba, the University of Manitoba tested the capabilities of CANMET's equipment, and is looking to buy a similar piece of equipment in a cooperative venture with INCO, Hudson Bay Mining and Resources and the Natural Sciences and Engineering Research Council.

Technology (START) program, $600K was allocated in 1983 for capital acquisition, and the next two years were spent on research and programming to get the machine fully operational.[2]

At the time that CANMET's new image analysis equipment was being acquired, some initial publicity (e.g., an article in the journal of the Canadian Institute of Mining and Metallurgy, and presentations at technical conferences of the Canadian Mineral Processors, the Canadian Metallurgy Society, and the Canadian Institute of Mining and Metallurgy general meeting) produced a strong response and demand for analytical work. Requests, in fact, came in long before the equipment was fully programmed and ready.

Energy, Mines and Resources originally offered companies free mineral analyses with funding under the Department's START program. By the time the equipment was ready in 1985, demand had dropped due to the poor turn-around time of the first two years. Further publicity, through paper presentations in 1986 brought the demand up again, with requests for image analysis work remaining fairly stable since then. Fees were introduced in 1987, at approximately full cost recovery levels.

2. ISSUES

CANMET has moved from providing a free service to a full cost-recovery service. Most of this case's issues, identified below, relate to that difference in approach.

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[2] The START program was introduced in FY82 to provide special assistance to the mining industry during a severe recession. It included $5 million in funding for EMR programs supporting the mining industry.

1. Has cost recovery prevented some users from accessing the system? If so, what losses have occurred to Canada as a result of that situation?

2. Has the service been maintained at a level that industry would expect? That is, has capability been maintained or improved, in terms of cost-effectiveness to industry?

3. Has the demand for CANMET services been managed in such a way as to optimize the services available and provided?

4. Has the presence of similar capabilities at the New Brunswick Research and Productivity Council, and the coming capability at the University of Manitoba, strengthened or weakened CANMET's service?

5. Without a comprehensive analysis of the full dataset of image analysis projects and the client results, what can be concluded about the impacts of the service?

6. Has the equipment been used for the projects with the greatest economic payback?

7. Is re-investment sufficient to maintain CANMET's technological leadership?

3. METHODOLOGY

Data collection for this study included interviews with the CANMET manager responsible for the image analysis work, and with a non-random sample of the client companies.

The Mineral Sciences Laboratories do not keep records of the image analysis contracts separate from other contracted research performed for industry. Image analysis is seen within the Laboratories as one of many research techniques used for clients, and not as a separate service, project or program. As a result, no random sample of user firms could be developed. We relied on a list supplied by CANMET to illustrate the range of impacts of the image analysis services over time, and in different parts of the country.

The CANMET manager responsible for the image analysis work provided this list of some of the companies that have been clients of this service (and contacts at the companies). It is recognized that these firms are likely to be ones that have used the service more than once, and therefore are apt to be more positive about the benefits of the service, than the average client. We have tried to account for this fact in the findings.

The interviews with both CANMET officials and industrial clients focused on questions of how the technology benefitted the companies, the costs of performing the analyses, the impact that the analyses made to the mining companies, and the overall value of image analysis work for the firms.

4. FINDINGS

The CANMET manager of the work has indicated that approximately 250 image analyses have been undertaken since 1985. CANMET officials believe that roughly 80% of the projects have produced results which have helped the industrial client to recover more minerals. Increased recoveries can mean improved economics for a mine, or longer mine life, or both. It is recognized that many of these projects would have small scale impacts, based on the size of the firms that had requested the work. However, CANMET officials also estimated that at least 10% have had significant impacts.[3] Even the largest image analysis projects cost no more than $50K, while the average is around $5K. Some are as small as $500. For those cases where significant changes are made, the image analysis clearly provides very high leverage. The following sections examine the types of costs and benefits more closely.

Costs

The Cost Function

COSTS = Σ { (CANMET Capital Costs)
+ (CANMET Start-Up Research and Programming Costs)
+ (Annual Operating Costs)
– (Client Fees for Service) }.

CANMET Capital Costs

The original equipment costs for CANMET were approximately $600K in the spring of 1983.[4]

CANMET Start-Up Research and Programming Costs

An additional $200K was spent on research and programming in 1983, along with a similar amount in 1984, bringing the total start-up costs to approximately $1 million.

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[3] "Significance" is a very subjective judgement in this case. Actual impacts are not known with great specificity. The term has been used where at least $1 million of changes have been stimulated. In some cases, very large investments (>$100 million) resulted from the image analysis.

[4] Funding provided under the START program.

Depreciation

The equipment is expected to have a 15 year life span. If we depreciate this $1 million capitalization cost over ten years, then the annual charge should be approximately $100K. An update for the machine was purchased in May 1989 for $100K.

Software is usually depreciated in industry at either 33 $^1/_3$% or 50%. In the estimates below, we have treated research and initial programming as part of the hardware capitalization, and depreciated it on a 10% straight-line basis. That approach should be reconsidered as it is can lead to under-investment in research and software development.

Operating Costs/Client Fees for Service

Charges to clients are on the order of $340/hour for machine and operator, with most analyses taking anywhere from one to five hours of machine time, plus four days of professional time.[5] Estimates have been given that a client can have three samples tested for about $5K. Since that incorporates approximately one week of professional time, the effective charge-out rate is $125/hour, for machine use, professional time, expenses, and support. Especially given the level of technical sophistication and the high capital cost of the equipment being used, this rate compares quite favorably with normal professional fees for lawyers, accountants, and even engineers.

CANMET officials are concerned that these fees may be prohibitive for smaller companies.[6] Yet the demand for the image analysis testing seems to have been strong and steady for the past eight years. The equipment, in fact, has been operating constantly for the past eight years. Whether or not the equipment has been used during that time for the projects with the greatest economic payoff, however, remains unknown since that criterion is not part of the process by which projects are selected.

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[5] Consisting of: one day to write the macro for the machine, one day to set up the samples for analysis, and two days to write the accompanying report.

[6] It was noted that the University of Manitoba and the New Brunswick Research and Productivity Council are charging significantly less (e.g., $65-$100/hr.) for similar analyses. Indications from CANMET clients, however, suggested that the expertise at CANMET was well worth the higher cost for the companies that used the federal government service.

Image Analysis Services, MSL
Summary of Costs (current dollars)

Year	Capital	Operating[7]	Recovery[8]	P/L Net	Depreciation[9]
1983	-$800K	0	0	0	-40K
1984	-200K	0	0	0	-90K
1985	0	-200K	0*	-200K	-100K
1986	0	-200K	0*	-200K	-100K
1987	0	-200K	250K	50K	-100K
1988	-100K	-200K	250K	50K	-105K
1989	0	-200K	250K	50K	-110K
1990	0	-200K	250K	50K	-110K
1991	0	-200K	250K	50K	-110K
TOTALS	-1,100K	-1,400K	1,250K	-150K	-865K

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[7] We have used the project manager's estimate for fully-loaded personnel and operating costs in the start-up phase, then continued the same level of charge to present. The project manager has since been promoted and only spends 25% of his time on this service, while a Research Scientist (RES-2) has been hired to conduct most of the analyses.

[8] We have based our recovery estimate on the following data. Average charge for service: $5K; steady demand, machine always in use: assuming 50 weeks per year operational; the average $5K study takes approximately one week of professional time. Thus: 50 studies per year @ $5K average, makes revenue of $250K. Conversely, we noted that about 250 studies have been completed to date; over 6-7 years, that suggests an average of 40 studies per year. That would make revenue $200K per year, the same as estimated operating costs.

[9] For the purposes of this analysis, we have capitalized equipment and R&D costs in the year in which they were incurred. We then charged depreciation on the basis of 5% in the year in which capital costs were incurred, followed by 10% straight-line for the next nine years, finishing with the final 5% in the eleventh year.

* Funding provided by START program for 1985 and 1986. After that, revenues are primarily from the mining industry. START funding could be treated as program revenue, but was excluded here since it was also drawn from general tax revenues.

Net costs to EMR have changed considerably. In the start-up period, there was little off-setting revenue, with capital costs provided by the START program. Then in 1985 and 1986, services were provided free-of-charge to industry, being underwritten by START. Since then, demand has remained steady, despite the imposition of cost recovery measures which appear to be generating more revenue than the annual operating costs.

While these numbers should be considered as quite approximate, they suggest that the service operates at a profit, at least until depreciation is counted. Provided that the capital costs can be justified by external benefits and indirect recoveries (which seems highly likely - cf. "Benefits" section below), it is apparent that the mining industry is paying the costs of operating this service. Alternatively, capital and startup costs could be treated as sunk costs, expensed to the START program. In that case, the only depreciation charge against this program relate to the 1989 update, and ongoing R&D costs to maintain its leadership position.

Benefits

In our analysis of this case, we have had to rely on anecdotal evidence and a very limited number of specific micro-cases. Extrapolation from this non-scientific basis has been necessary, but should be treated with considerable caution. Nonetheless, it is apparent that the value of external benefits to the mining companies and Canada far exceeds the capital costs of the service. As we have shown above, the direct revenues now equal or exceed the operating costs. In order to establish a positive net benefit, only the capital costs of approximately $1.1 million need to be covered by external values. The return has probably been much greater than break-even.

It is recognized that refinements of the image analysis routines are being made, which will continue to improve the speed with which the analyses can be done for clients. Any reported benefits are likely to be increased in the future, as the routines for measuring different parameters of a mineral specimen are made more efficient, and the resulting hourly rate for performing the analyses decreases.

Some of the types of benefits that have been realized are described below.

The Benefit Function

BENEFITS = Σ { (More Efficient Production for Mining Companies)
+ (Environmental and Safety Benefits) }.

More Efficient Production for Mining Companies

For one of the companies that used CANMET's image analysis service several times, the CANMET work was the key to their research program. It assisted in determining why a particular type of crystal could not be liberated totally under their ordinary production process. With resulting changes to their production process (now being tested) it is expected that the mine life and the employment of 160 workers will be extended by seven to ten years.

Image analysis was particularly useful in this situation as the mineral being extracted could not be evaluated at a diameter of 100μ with ordinary microscope techniques. Imaging with the CANMET electron microscope was used, in this case three times, to better understand the mineral characteristics, including the composition of its core and contour.

The results of this work are that the mine currently expects that the same number of employees will be able to handle an increase in production, with anticipated additional revenue being more than $1 million per year. All of this increase in revenue will come fromforeign sales.

For another mining company that usedthe image analysis service, recovery of a particular mineral has sine been increased from 77% to 84%, resulting in another substantial economic gain. The image analysis work helped to identify the composition of the ores, and to identify how recovery for one of the minerals could be increased through the use of further grinding of the ore. This firm has suggested that not all of the increased production (and sales) would be directly attributable to image analysis, but that it certainly was a major factor.

Both of these cases reflect the particular role that image analysis plays in the mining industry. It enables research into complex ores, as a means to identify the particular characteristics of the material. With that knowledge in hand, extraction processes can be refined to significantly improve the economics of an ore body. The changes can be manifested several ways:

1) Increased extraction of existing known minerals;
2) Additional extraction of associated minerals;
3) Development of extraction methods which make an ore body economically viable.

Thus we should expect to see effects which both bring new mines into production, as well as improve the economics of existing mines.

Image analysis, then, should be seen as a highly sophisticated research service. When combined with knowledge of production processes and capital investment, it can produce multi-million dollar gains. There is evidence that CANMET's service has done that many times over.

Environmental and Safety Benefits

Environmental and safety benefits are not the purpose of this service and none have been identified to us. It is conceivable that either benefits or costs could arise as a result of changes in production processes and extractions. By-products may also change. Intuitively, it seems that more complete extraction of minerals is likely to reduce environmental problems from tailings in most cases, but this cannot be counted as a benefit without more detailed examination.

5. CONCLUSIONS

Comparing costs and benefits leads to the following conclusions:

Participant	Costs (PV)[@]	Benefits (PV)[@]
CANMET/ START/ Govt. of Canada	$2 million	~$1.25 million[10]
Service clients (mines)	~$1.25 million	$ millions[11]
TOTALS	~$4.25 million	Several million $

Net Present Value: Several million dollars.

Break-Even/Payback: Undefined, but probably less than three years. For CANMET alone, the service is more than breaking even on current operations now, but is unlikely to recover its initial capital costs at current rates. The $400K loss supported by the START program in the first two years of operation is likely to be retired in eight years (i.e., by the end of 1994) at present rates of recovery.

Estimated Rate of Return: If the NPV is $10 million, then the rate of return has been ca. 28%. If NPV is $100 million, then the rate of return is ca. 280%

By itself, image analysis produces few direct benefits. Its real value lies in the knowledge it gives about ore bodies. Armed with that knowledge, mining engineers can develop more efficient means of extracting minerals, thus improving the economics of their mines.

[@] Reported in 1990 constant dollars, and rounded to the nearest thousand (000).

[10] Fees received from the mining companies for services since the end of the START program.

[11] Several of the micro-cases reported substantial savings resulting from changes to their production and recovery processes based on the information gleaned from the image analysis work performed by CANMET. for one, the change was worth $2-3 million a year in improved profitability, based on < $50K in research fees to CANMET. The Image analysis lab has conducted over 200 research projects during the period covered here.

It is apparent that demand for image analysis services is growing in Canada. CANMET is broadly recognized as the leader in this field, because of its equipment and skilled personnel.

The mining industry is paying for the operating costs of the service. Capital costs have been only partly covered. Due to lower-priced services from a PRO and a university, there may be little room to further increase prices, despite CANMET's premium quality work. Nevertheless, capital costs support by the taxpayers appears to have been amply rewarded through improvements in the Canadian mining industry.

Despite little apparent competition on the world scene, CANMET is doing very little international business. There appears to be room for its services in other countries,[12] provided Canada wishes to share this expertise. At the present time, however, there appears to be little extra capacity and policy directs services toward Canadian firms.

CANMET's role is migrating from that of a sole Canadian provider of image analysis services to that of Canada's leading national provider. That change may open some export possibilities. It also requires a significant level of re-investment to maintain a state-of-the-art capability. As lower cost services develop, CANMET will increasingly be called upon to handle the most difficult (and valuable) assignments. As technology improves, CANMET will have to stay at the forefront, or fundamentally change its business strategy for this service. There is some concern that investment in R&D, particularly in software engineering, may not be keeping pace.

One way to address this concern would be to treat the Image Analysis service as a distinct business service with its own accounts. While the 10%

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[12] The Australians continue to challenge CANMET for international leadership in technical journals and new developments. The US public facility was shut down last year, apparently for lack of work. Other countries may have similar capabilities, but do not appear to be as active in the international scientific community.

straight-line depreciation rule we used may be an appropriate guideline for hardware, software should be replaced at a much higher rate. By tracking costs more specifically, CANMET could use such a guideline to ensure it maintains the national productivity of this service.

CHAPTER 11

MOBILE FOUNDRY LABORATORY

SUMMARY

Mobile Foundry Lab

Development in 1984 of a mobile laboratory (on a truck base), assembled to travel to small and medium-size foundries across Canada. Staff of four included specialists who performed on-site analyses of foundry operations.

Timing: 1984, 1985 - CANMET delivery; 1986, 1987 - NRC/PROs.

Initial Capital Cost to CANMET: $323K (1990 $).

Cost of Program: $509K/year (1990 $).

Cost to CANMET: $417K/year (1990 $) for salaries and operating costs.

Participants: CANMET's mobile laboratory team visited 40 foundries in 1984, and 37 additional foundries in 1985. In 1986 and 1987 the mobile lab was operated by the Ontario Research Foundation (in Ontario and western Canada) and by the Centre de Recherche Industrielle du Québec (in Québec and eastern Canada). Roughly 20 foundries were visited in each of these two later years, including many of those visited in 1984 and 1985.

Status: The Mobile Foundry Laboratory ceased operation at the end of 1987. The lab was disassembled for lack of funding.

CANMET Roles: CANMET developed the laboratory, and operated it during 1984 and 1985. During 1986 and 1987, CANMET leased the laboratory to the two Provincial Research Organizations and provided technical expertise.

Benefits: Increased confidence for foundry operators; increased awareness of technical standards; small foundries able to bid on jobs requiring higher levels of quality.

Other Features: Industry devastated by contraction in late 1980s and early 1990s; program effect overwhelmed by external economic factors. Program revenue <10% of annual costs.

MOBILE FOUNDRY LAB

1. BACKGROUND

In 1983, CANMET determined that, of the roughly 250 Canadian foundries in existence at the time, there was a large number of small foundries (fewer than 100 employees) in need of production testing services. These foundries were usually too small to have in-house research labs to solve their problems, and were unable to afford the costs of consistent, external analyses of their techniques. When external analyses were contracted, they were done by independent labs, without the benefit of seeing the whole operation or talking to all of the employees involved. Thus, no knowledge about corrective measures was transferred.

Given this situation, CANMET developed and operated a mobile laboratory for foundries across Canada in 1984 and 1985. The lab was equipped to perform a number of tests for small and medium-sized foundries, which would not otherwise be able to benefit from on-site evaluations of their production techniques. Testing done for the foundries focused on: sand moulding and control, metal processing, and defect analysis.

In 1986 and 1987, CANMET leased the laboratory for $1/year to the Ontario Research Foundation[1] (ORF) and to the Centre de Recherche Industrielle du Québec (CRIQ) to operate in western and eastern Canada respectively. This new operation of the lab was part of a test to determine if the lab could be run successfully on a decentralized basis.

During the years that ORF and CRIQ ran the laboratory, NRC funding was used to offset most costs, but fees were still charged to the foundries. Roughly 20 foundries per year were visited by the Provincial Research

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[1] The Ontario Research Foundation has been renamed ORTECH since the time of the mobile foundry laboratory work..

Organizations. In 1987, NRC-IRAP funding ended. The laboratory was returned to CANMET, where the equipment has been used in other labs, and the truck remains as a crown asset waiting to be sold.

This cost-benefit analysis looks primarily at the two years in which the federal government operated the laboratory. It is noted, however, that analyses have been done by both CANMET and the two Provincial Research organizations regarding their own operations of the lab[2]. Where appropriate, those analyses are cited.

The mobile foundry laboratory was set up with $250K of capital funding. It was a fully equipped, mini-lab that would be able to perform on-site analyses of various aspects of foundry work.

In 1984 CANMET took the mobile foundry lab to forty foundries in Nova Scotia, New Brunswick, Prince Edward Island, Québec, Ontario, Manitoba, Saskatchewan, Alberta, and British Columbia. The following year, the laboratory visited 37 other foundries in Québec, Ontario, Alberta and British Columbia. (The table on the following page shows the breakdown by province of foundries visited in each year.)

The mobile foundry laboratory staff included four individuals who traveled to each site with the lab. The team members included: a sand specialist, a sand technician, a metals specialist and a spectrograph analyst.

Each visit was scheduled for one and a half days of research at the foundry, followed by meetings with management, and the writing of a confidential report. The original plan for the laboratory called for two site visits per week, but travel time requirements between foundries often made this schedule impossible. The number of visits per month in 1984 and 1985 is shown below.

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[2] Kanata Consulting Group for CANMET, An Evaluation of the Mobile Foundry Laboratory by its Clients, January, 1986. DSS File No. 09GR.23440-5-9153; and Kanata Consulting Group for CANMET, An Evaluation of the Visits of Mobile Foundry Laboratory by ORF and CRIQ, March, 1987, DSS File No. 09GR.23440-6-9200.

NUMBER OF FOUNDRY VISITS
BY PROVINCE AND YEAR, 1984-85

Province	1984	1985	Total
Newfoundland	0	0	0
Nova Scotia	3	0	3
Prince Edward Island	1	0	1
New Brunswick	1	0	1
Québec	6	6	12
Ontario	14	24	38
Manitoba	5	0	5
Saskatchewan	3	0	3
Alberta	3	4	7
British Columbia	4	3	7
Totals	**40**	**37**	**77**

During 1984 the mobile laboratory services were free of charge for the foundries. During the second year, CANMET started to charge some fees, and saw a slight drop in the number of foundries which expressed interest in having site visits[3].

In 1987, the team operating the mobile laboratory was given a Merit Award for service to the foundry industry by the Department of Energy Mines and Resources. The following year, Treasury Board bestowed its Award of Excellence on the team members for their work.

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[3] Each year, small and medium size foundries across Canada were contacted to determine if they were interested in having the mobile foundry visit their facility. Schedules for the visits were then prepared to visit as many as possible of the foundries that requested visits.

NUMBER OF FOUNDRY VISITS PER MONTH
1984-85

	1984	1985
January	3	6
February	1	4
March	6	3
April	2	0
May	3	0
June	5	7
July	0	1
August	7	5
September	5	3
October	4	4
November	4	1
December	0	3
Total	40	37

2. ISSUES

Previous evaluations of the Mobile Foundry Laboratory focused on benefits derived from the site visits, but did not address any of the costs involved in administering the program. These studies by the Kanata Consulting Group focused on gross savings realized by a sample of different size foundries, and extrapolated those findings to the industry as a whole. New employees hired as a result of these savings were also identified and extrapolated to the whole industry.

The elapsed time since the mobile foundry visits was expected to influence the level of residual benefits. Changes in general economic conditions have caused significant hardship for this industry, including the closings of 33% of the firms that the Kanata Consulting Group interviewed in 1986.

The primary issues to be addressed at this time are, therefore:

- To what extent do the benefits reported in 1986 and 1987 still apply?

- To what extent were the costs of establishing and operating the mobile lab offset by benefits?
- How would fee recovery affect the use and benefit/costs of the program?

3. METHODOLOGY

We met with the program manager at CANMET and the managers of the Provincial Research Organizations that took over operation of the laboratory in 1986. We also selected a random sample of five foundries from those that the mobile unit visited in 1984-85.

We recognize that the sample size of this assessment is significantly less than that of the 1986 evaluation. The depth of the interviews and the consistency of the responses across the different size and type of foundries in our current analysis, however, leads to confidence in the findings.

Of the firms in our sample, one refused to participate, as it was too busy. The remaining four included one in New Brunswick, one in Alberta, and two in Ontario. The management of each of the four agreed to participate in an in-depth interview. One of the Ontario foundries is among the ones that have gone out of business since the mobile lab visit, but we were able to find the owner of the foundry, and discuss the value of the visit to a firm that had since ceased to operate.

In each of our interviews the management personnel had to rely on memory, since no recorded data of the original lab visits (and their impacts) were available. Where subsequent visits had been made by the ORF and CRIQ teams, we tried to ensure that comments were clearly related to the original 1984-85 visits by CANMET.

4. FINDINGS

The foundry managers were generally positive about the mobile laboratory visits. They also found value in the fact that the lab analyses were done on-site. Each manager had greater confidence, as a result, that the findings were derived with an understanding of his whole operation, including the opportunities, limitations and personnel of the firm. Foundry management also believed that the visits generated educational value for the foundry staff. Staff were able to realize that there were correct methods for foundry operations, and were personally shown better ways of doing things, on-site. On-site analyses also resulted in immediate correction of problems, without the delays involved in sending samples out for analysis.

The foundries indicated that they regularly sent samples of metals to independent laboratories for testing. That procedure could be done as often as every two to three weeks. Sand testing was much less frequent, however, with heavy reliance on the expertise of veteran workers.

The managers indicated that more frequent visits would be helpful, if the lab technicians on the mobile lab team were experts who could also communicate well. The CANMET team with the lab received great praise from the managers in our interviews. Expertise on the teams manned by the Provincial Research Organizations was not felt to be as strong.[4]

The final reports submitted to the foundry came several months after the visits. This turn-around was considered too slow. Managers recalled that not all of the recommendations discussed at the time of the visit showed up in the final reports. As a result, meetings right after the analyses proved more valuable than delayed final reports. It was noted, however, that the reports did show whether or not the foundry met the ASTM standards, and how it compared to other foundries. Foundries that met the ASTM standards were able to use this final report for marketing purposes.

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[4] It is noted that one of the recommendations of the 1986 evaluation was a need for regional mobile labs -- provided they were staffed by a team of experts comparable to those from the Ottawa - CANMET team. In 1987 an evaluation of the ORF and CRIQ operations of the mobile lab identified that the ORF team's expertise in metal processing was insufficient to address the needs of larger foundries. The current findings with regard to expertise confirm this earlier suggestion.

Foundry personnel recalled that tests in the following areas were performed: metal hardness, tensile strength, temperature of the sand, the loss of ignition or amount of chemical burned off the sand, metal composition, metal temperature, mechanical properties of green sand and no-bake sand. These tests were quite helpful, especially as the results were interpreted with an awareness of other aspects of the foundries' operations.

Costs

The Cost Function

COSTS = Σ { (Foundry Personnel Costs)
+ (Fees for Mobile Laboratory Visits)
+ (CANMET Capital Costs)
+ (CANMET Personnel and Operating Costs) }.

Foundry Personnel Costs

For the foundries involved, the costs of the first set of visits were generally limited to one to three person day(s) of time (estimated at $200-$600/day or $600-$1800/ visit for salary and benefits) to work with the mobile laboratory team in setting up the tests and in hearing final recommendations. Capital and operating costs for the visit were minimal. Internal foundry costs are, therefore, estimated at the mid-point of the range ($1200/visit) for the purpose of this analysis. Foundry costs, then, are estimated as $62K and $55K for 1984 and 1985 respectively (1990 $).

Fees for Mobile Foundry Visits

No fees were charged by the mobile laboratory during the 1984 visits. In 1985, however, fees were charged at the rate of $500 for small (usually non-ferrous) foundries and $1000 for larger foundries (those with more than 80 employees). In 1986 and 1987 a flat fee of $500 per visit was charged to all foundries. Revenues from the fees in 1985, 1986, and 1987 were, therefore, approximately $30K; 12K; and $11K (in 1990 $). The 1985 fees were paid to CANMET; the 1986 and 1987 fees were revenues to the PROs.

CANMET Capital Costs

For the federal government, the costs included capital costs during the first year of operation. The original capital outlay was $250K ($323K in 1990 $).

CANMET Personnel and Operating Costs

Personnel costs were estimated at $240K per year ($310K and $299K in 1990 $ for 1984 and 1985 respectively), and other operating costs for running the mobile lab were estimated at $100K per year ($129K and $124K in 1990 $) by CANMET officials. (1985 operating costs were partly offset by the $30K received in fees during that year.) Over the four year period, personnel and operating costs were roughly $382K/year in 1990 dollars.

Total Costs of Program

Net costs for the program (excluding foundry personnel time) were $763K in 1984 (including capital costs of $323K); $423K in 1985; $458K in 1986; and $371K in 1987.

While net costs are higher during the first two years, Table 3 shows that operating costs were actually higher in 1986 and 1987 with PRO/IRAP funding than in 1984 and 1985 with CANMET funding the operation. Personnel costs, however, were higher during the earlier two years. The simple explanation is that the two offset each other, and that the two sets of numbers are not representing exactly the same costs. A closer

NET COSTS
MOBILE FOUNDRY LABORATORY
(in 1990 constant $)

Item	1984	1985	1986	1987
CANMET COSTS				
capital	$323K	$ 0	$ 0	$ 0
personnel	$310K	$299K	$ 10K	$ 10K##
net operating	$129K	$ 95K###	$ 0	$ 0
subtotal	$763K	$393K	$ 10K	$ 10K
FOUNDRY COSTS				
personnel	$62K	$55K	$29K	$27K
fees	$ 0	$30K*	$12K**	$11K**
subtotal	$62K	$85K	$41K	$39K
ORF & CRIQ COSTS				
personnel	$ 0	$ 0	$167K#	$160K#
NRC - IRAP COSTS				
net operating	$ 0	$ 0	$269K	$189K
Total Costs	**$825K**	**$478K**	**$487K**	**$398K**

Notes:

# Subtotals and Totals do not necessarily equal sum of numbers being added due to rounding.

## estimated rates for administrative and technical assistance to the PROs.

###operating fees for 1985, 1986, and 1987 are net of the amount of fees that the foundry industry paid for the mobile lab visits. ORF and CRIQ operating costs are roughly one-half of the operating costs incurred by CANMET due to the fact that they visited only half as many foundries .

* based on fees of $500 for small firms (less than 75 employees) and $1000 for larger firms (75 or more employees), and estimates drawn from earlier studies that 70% of the firms surveyed in 1986 had less than 75 employees.

** based on fees of $500 to all firms visited, as identified by officials at ORF.

consideration, however, is warranted, given the fact that ORF and CRIQ together visited only half the number of foundries that CANMET did.

The ratio of personnel and operating costs to number of visits per year is:

- 1984 - $11.0K per visit
- 1985 - $11.4K per visit
- 1986 - $22.4K per visit
- 1987 - $18.0K per visit.

Clearly, the costs of operating the program were less, on a per visit basis, when managed by CANMET, than by the Provincial Research Organizations. As will be shown in the following section, the benefits were also reportedly higher during the first two years of the program as well.

Benefits

The Benefit Function

BENEFITS = Σ { (Quality Improvements)
+ (Educational Benefits for Foundry Employees)
+ (Production Level Increases)
+ (Impact on Sales and International Trade)
+ (Health and Safety and Environmental Benefits) }.

Quality Improvements

The managers at some foundries indicated that the recommendations did show them how to improve the quality of their products. Where time efficiencies were recommended for one part of a firm's production cycle, however, they were offset by suggestions of longer times in other parts of the production cycle.

Educational Benefits for Foundry Employees

Educational benefits resulted from the visits for foremen and other employees, particularly for the areas of operation related to sand testing, and improved quality control. Specifically, when foundry staff discussed methods and procedures with the mobile lab team, new methods were sometimes introduced directly into the production process.

Production Level Increases

Seven to eight years after the CANMET visit, managers did not believe that production levels had increased as a result of the mobile laboratory visits analyses.

Impact on Sales and International Trade

No impacts on sales and international trade were recalled. Smaller Canadian foundries tend to serve local and regional markets if they are producing custom-made products. For foundries that provide a particular product to a larger market, it does not appear that improvements based on the mobile lab recommendations resulted in long term increases in sales (either domestically or internationally) or contributed to a decrease in imports of similar products.

This finding confirms both the 1986 and the 1987 evaluations of the mobile foundry laboratory; but it cannot be verified independently. In light of the severe shrinkage in the industry, even survival may be a real benefit. Our methods did not test the survival ratios of visited firms against non-participants. Such an analysis would also have to account for differences in prior condition.

Health and Safety and Environmental Benefits

We also found no evidence of health and safety or environmental benefits stemming from the mobile lab recommendations. All evidence suggests that the mobile lab teams concentrated their attention on production efficiencies and product qualities of the foundries. From the comments made by foundry managers, however, there do appear to be opportunities for such improvements. Any revival of the mobile foundry laboratory in the future should examine the potential to add assistance in occupational health and safety issues.

SUMMARY OF BENEFITS

Quality Improvements	some
Educational Benefits	significant
Production Level Increases	unknown
Impact on Sales & International Trade	unknown
Health and Safety & Environmental Benefits	unknown

Overall Benefits

Most of the comments indicated a good level of satisfaction with the visits. Recommendations generally helped the foundries improve their quality control procedures. With subsequent improvements to the quality of their products, most of the managers we talked to believed that their products had gained greater acceptance in the market. But they added that any increase in sales that may have been attributable to their adoption of recommendations was for the most part offset by the costs of adopting the recommended improvements.

On a no-cost basis, the visits were well worth the foundry management's time. Any costs for the service, however, must be weighed against alternative testing costs. Estimates of $40/sample for sand testing for independent lab analysis were provided by one foundry. Quarterly visit fees of $100-200 are perceived to be an acceptable cost level for the smaller foundries. These rates are much lower (on a per visit basis) than the $500-$1000 charged by CANMET in 1985 or the $1-2K per annual visit that was identified by the firms as reasonable in the 1986 and 1987 evaluations. They are, however, comparable on an annualized basis, and they do reflect the more difficult current economic climate.

Most foundries had positive recollections of the visits (even if they were not influential in the firm's bottom line). One foundry, however, received recommendations from the mobile lab team that they shouldn't change anything in their operations. In this case there were benefits that the firm received in terms of increased confidence in its operations and recognition that it was meeting ASTM standards. The management, however, felt that there were no apparent benefits resulting from the visit, or the time it required. The management of the foundry has indicated that this null finding did not even provide them with a sense of increased confidence. For firms such as this one the costs of foundry personnel time and laboratory costs appear to have had no perceived benefits.

Comparisons Over Time

In January of 1986, the Kanata Consulting Group completed "An Evaluation of the Mobile Foundry Laboratory by Its Clients." In this analysis, 41 of the first 76 foundries visited by the lab in 1984 and 1985 were polled for information regarding the value of the service. The report indicates that $793K of savings had already been realized by these 41 firms and an estimated $5.2 million more was expected to be generated over the following five years based on technological improvements suggested during the mobile lab visit.[5] These assessments of savings are reported by size of firm, and identified that there was likely to be a savings of $3.9K per employee for firms with 50 or fewer employees, and $1.7K per employee for those with more than 50 employees.

The 1986 evaluation also found that 15 professional or technical personnel and 8 unskilled workers had been hired by the 41 firms interviewed as a result of their visits. The conclusion was also drawn that if all Canadian foundries were visited by the Mobile Lab and hired new employees at the same rate following the visits, an additional 90 professional and technical jobs would be created along with 48 unskilled jobs in the foundry industry.

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[5] Kanata Consulting Group for CANMET, January, 1986. Executive Summary.

The foundry industry, however, has gone through considerable changes since 1986. Out of the 77 foundries visited by the Mobile Lab in 1984 and 1985, 25 (or 33%) have since ceased operations. This large number of closings is generally reflective of the changing economy in the late 1980s and its impact on the foundry industry. Current data indicates that 95 out of approximately 250 foundries across Canada (or 38%) have ceased operations since 1983.

The results of our discussions with the foundries, seven to eight years after their initial visits, are generally positive but significantly less enthusiastic than those reported in the 1986 evaluation. Several factors explain this variation. Time delays in the evaluation substantially alter the results. Intervening variables, such as changes in business opportunities, changes in the overall economy, or improvements to manufacturing procedures, will act to diminish the importance of the visits to foundry management over time. Despite advance arrangements for the meetings, the managers in each of our interviews relied totally on memory of costs and benefits. They did not have any records of the mobile lab visits or its impact on their businesses readily available.

Another significant factor that accounts for some of the differences between the 1986 study and the foundry managers' current assessments of the Mobile Lab is the large percentage of foundry closings in recent years. If the 1986 study were being done today, its findings could not be projected over such a large industry. Twenty-eight of the original 77 (36%) foundries visited are no longer in operation today. Fifteen of the 41 (37%) that were evaluated in 1986 have been closed, as have 95 of the estimated 250 foundries that made up the industry in 1983 (38%).

By applying this 38% closing rate for the foundry industry as a whole, the 1986 study's estimates of 250 foundries in Canada would more likely be 155 firms today. Industry-wide projections for new employees hired as a result of the lab visits (90 professional and technical jobs and 48 unskilled new jobs) are unlikely to have been fully realized. Instead, the industry has seen huge layoffs in recent years. By applying the 1986 study averages of 50.5 employees per foundry in B.C., 56 in the Prairies, 103.4 in Ontario, 46.5 in Québec, and 24.2 in the Maritimes to the known 28 closed facilities that CANMET visited, we estimate that roughly 2300 jobs have been lost from the 77 foundries. Projecting these averages to the 250 foundries believed to exist in 1986 we find that approximately 7500 jobs have been lost across Canada in this industry in the last five years.[6]

Savings that resulted from implementation of the mobile lab advice, as reported in 1986, must also be adjusted at this time. A longer time perspective seems to have reduced the managers' sense of the importance or magnitude of savings that resulted. The 1986 study reported an average of $19K in actual savings per firm visited and $127K per firm ($5,208K for 41 firms) in expected savings for the period 1986-1990. Given recent plant closings among 15 of the 41 firms that were surveyed in 1986, it is expected that the savings per firm that resulted from the visits were at best $9.3K per firm, and quite probably much less. The benefits to the Canadian economy evidenced earlier by company savings produced by the mobile lab are likely to have been significantly reduced, if not eliminated, through recent business losses and the resulting tax losses.

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[6] These figures are only averages -- relying on a calculation of average number of employees per firm per region, and the known locations of 25 firms that have closed. We were unable to determine whether CANMET's 77 visits were to disproportionately large or small firms or whether closings among the 250 firms making up the industry were mainly small or large firms or firms from particular regions.

5. CONCLUSIONS

Participant	Costs (PV)@	Benefits (PV)@
CANMET/ Govt. of Canada	$1,206K	$30K
NRC (net)	$458K	$0
Provincial Research Orgs. (net)	$350K	$23K
Foundries participating	$173K	~$3,000K[7]
Foundries not participating	?	?
Foundry clients	?	?
Foundry employees	?	?
TOTALS	$2,187K	~$3,053K

Net Present Value: ~$866K.

Break-Even/Payback: second year.

Estimated Rate of Return: If the NPV is ca. $1 million over six years, then the rate of return has been ca. 8%. If NPV is ca. $3 million, then the rate of return is ca. 24%. Most of the benefits accrued close to the time of the Lab visits, however, so one could argue that the initial $5 million of estimated benefits occurred in the four operating years, making the rate of return for that period in excess of 37%. Returns since then have been negligible or at least unattributable.

It is difficult to draw conclusions about the costs, benefits and impacts of the Mobile Foundry Lab after a lapse of more than four years in its operation. Intervening factors during the past four years have influenced the impact of the visits, as well as the foundry managers' perceptions of the Lab's value. It appears from our analysis, however, that the Mobile

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@ Reported in 1990 constant dollars, and rounded to the nearest thousand (000).

[7] See above for sources in 1986 study and our discounts since.

Foundry Lab did have a significant impact at the time that it operated. Substantial savings to the visited foundries were reported, along with new employment.

When the Mobile Lab was operated by the Provincial Research Organizations in 1986 and 1987, fewer foundries were visited each year and the levels of savings, resulting employment and praise for the operations were reduced. Benefits from the PRO visits could be expected to be less than half those resulting from the CANMET visits given that only half as many foundries were visited, and the quality of the PRO service was not considered to be as strong. Differences in the general industrial/economic conditions of the two time periods were not sufficient to be a major influence in those comparisons.

In the years since 1987, a number of factors have further reduced the impact of the Mobile Lab. Most importantly, the Lab has not operated for four years, and the economic recession has seen more than 1/3 of the foundries across Canada close their operations. Over time, even an activity with a major economic benefit will have a reduced importance for the managers, if it is not continued.

Our analysis does not suggest that the earlier evaluations of this program were invalid. Rather, over time, without continued activity and with other intervening variables, the current and continued value of the benefits has been reduced.

The government's costs for each visit averaged about $12K, while recovered fees returned only a maximum of $1K per visit during the second year. Given the foundry manager's level of willingness or ability to pay for the service, it is unlikely that higher fees could be realized for this service. The $11K net cost per visit must therefore be weighed against the other value received from the program.

While the economic benefits from the original visits are no longer significant to foundry managers, the educational benefits and quality awareness still remain very valuable to foundry managers and workers. These non-measurable benefits are important, and have not been provided in any other form to the foundries since the termination of the mobile foundry lab. Foundry managers, in fact, indicated that they would like to see some form of the mobile laboratory re-instated, as they believe the on-site analyses and methods advice was quite useful to them.

Given the industry's dramatic losses in the last five years, the incremental benefits provided to some firms have likely been overwhelmed. We were not able to estimate incrementality of the Lab in this environment, but suspect that it is considerably higher than most foundry managers acknowledge. Improved quality control and a more aware work force may well have made a difference in simple survival of Lab participants.

CHAPTER 12

WELD ZONE CORROSION

SUMMARY

WELD ZONE CORROSION RESEARCH

Research undertaken in cooperation with the steel industry and manufacturers of welding materials to test the best composition of steel and welding materials for use on ice breakers (under cold, icy, salty, abrasive conditions).

Cost of Program: $107K/year during years 1984-1989 (in 1990 $).

Cost to CANMET: $32K/year during 1984-1989 (in 1990 $).

Participants: CANMET, Algoma Steel, Stelco, Canadian Liquid Air, Fleet Technology, Canadian Coast Guard, Lincoln Electric.

Status: Research was completed in 1990. Implementation deferred indefinitely due to weak market conditions.

CANMET Roles: Coordination of research, part of testing of welding materials for corrosion potential.

Benefits: Better knowledge of steel and weld compositions, and welding procedures that will reduce corrosion of weld zones under highly abrasive cold, salt water conditions.

Other Features: Some technology transfer to pipeline applications. Research was begun with high expectations for application to polar ice breaker and Hibernia oil rig construction. Indefinite postponement of those programs has limited the value to repairs and innovative new applications, such as pipelines.

WELD ZONE CORROSION RESEARCH

1. BACKGROUND

Due to high abrasive conditions caused by ice in salty northern waters, the paints used to protect steel and weld zones do not adhere for as long, and the steels and weld zones are prone to higher and faster levels of corrosion, than on other types of ships or rigs. As a result, the weld zones between steel plates used in ice breakers have traditionally been a problem for the Canadian Coast Guard.

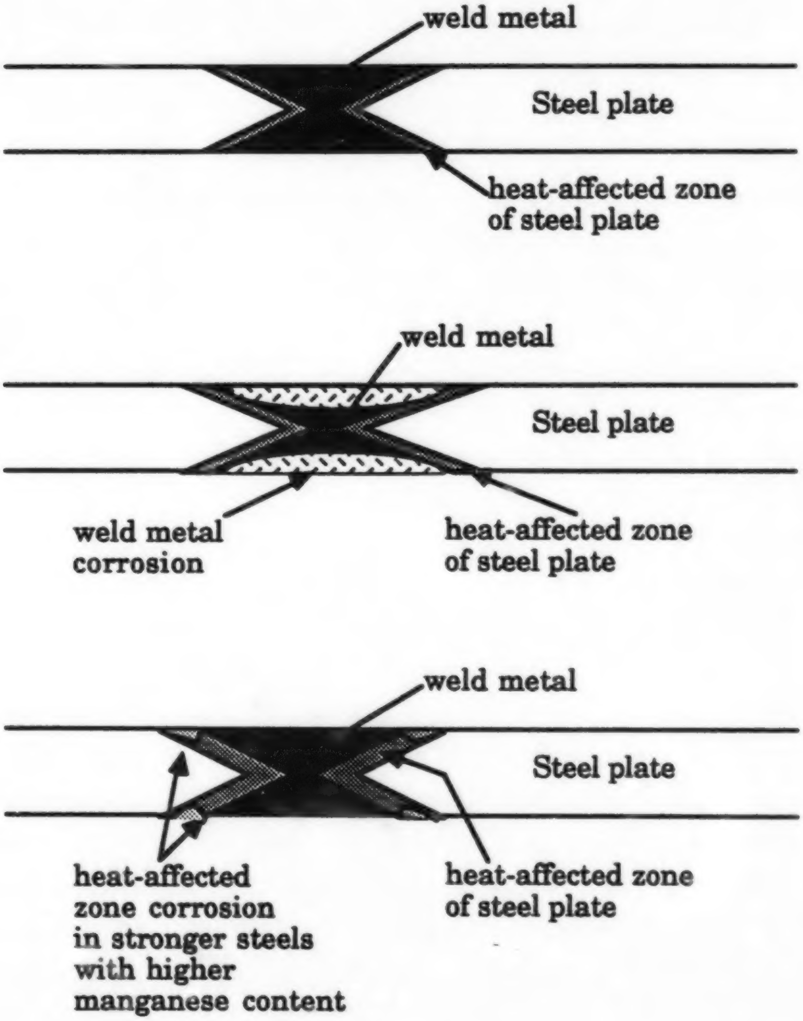
In 1984, the Canadian Government launched a set of research projects to look at weld zone technology for ice breakers in an attempt to minimize the corrosion potential, and to develop Canadian expertise in this area. The Norwegians had capabilities in this area, but were not licensing their technology. The resulting Canadian research focused on optimizing the composition of steels in order to reduce corrosion in ice breakers, in combination with optimizing weld metal composition and welding procedures. Different forms of corrosion were also studied, to determine the conditions under which they appeared.

The first project looked at 11 different steels, in an attempt to identify the composition of steels that would generate reduced weld zone corrosion. (See Diagram 1.) Given the fact that the Canadian Coast Guard operates a large fleet of ice breakers, and was at the time very interested in developing the Polar 8 ice breaker, this work was very timely.

Subsequent work looked at:

- different welding procedures that would result in reduced corrosion;
- different weld metal compositions that minimize corrosion; and
- the combination of different steels and welding consumables that result in reduced corrosion.

DIAGRAM I
CROSS SECTION OF WELDING ZONES


weld metal
Steel plate
heat-affected zone of steel plate
weld metal
Steel plate
weld metal corrosion
heat-affected zone of steel plate
weld metal
Steel plate
heat-affected zone corrosion in stronger steels with higher manganese content
heat-affected zone of steel plate

Throughout this work, Fleet Technology Ltd. of Kanata and CANMET provided independent testing facilities. Both organizations had their own unique set-ups for speeding up the corrosion process and monitoring the results. Other industrial participants worked on various stages of the research, supplying steel plate, electrodes, or developing welding procedures. The research very specifically included as wide a range of industrial participants as possible, in order to ensure that the results of the research were disseminated and used throughout industry.

CANMET contributed to much of the research on weld zone corrosion for ice breakers through: cost sharing of the research with industry; testing for corrosion potential of samples; and administration or monitoring of the research projects. CANMET maintains a facility for tank tests of steel plates in cold, salt water conditions, thereby facilitating the testing component of the research.[1]

2. ISSUES

The weld corrosion research for ice breakers was most concerned with identifying the composition of steel that would be least likely to corrode under abrasive conditions. It identified that the manganese composition of the steel influenced the extent to which the steel would corrode, and the ways in which that corrosion appeared at the weld zones. While higher levels of manganese resulted in stronger steels, they also resulted in higher corrosion potential for the steel itself in the heat-affected zone.

Different participants in this research (CANMET, the Canadian Coast Guard, welding electrode manufacturers, steel manufacturers) had their own interests in this research, and each would use the results in their own way. The resulting value of the work was, therefore, likely to be different for each type of participant. The first question that this analysis addressed was, therefore, "What was the balance between benefits and costs for each of the participants and for the research as a whole?"

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[1] More complete descriptions of CANMET's contributions are described under Section 4- Findings, below.

The work was initiated under the presumptions that the Polar 8 ice breaker would be built, and that the work would have other applications for cold water structures (e.g., Hibernia drilling platforms). With recent economic conditions and government priorities and policies, such projects have been put on hold. The current value of the research is, consequently, different than that which was foreseen at the time of the original work.

This analysis, therefore, addresses the questions of:

- Would the benefit/cost ratio have been greater than 1 if the Polar 8 and Hibernia projects had proceeded as envisioned in the mid-1980s? and
- Given that these projects have not proceeded, what benefits have been salvaged?

3. METHODOLOGY

Our review of this CANMET research, started with an in-depth interview of the program manager at CANMET, in order to identify the scope of the work, the main issues as seen by CANMET, the government's objectives in the research program, and the industrial participants.

Each of the Canadian industrial participants was subsequently contacted, and interviewed in depth by personal visits or (in two cases) by telephone. Our purpose in contacting the industrial participants was to identify their role in the research, their costs, and their perceived benefits.

4. FINDINGS

The weld-zone corrosion research is divided into several components:

1. Research between Algoma Steel, CANMET, and Fleet Technology to test the resistance to weld zone corrosion of 11 different steels;
2. Research between the Canadian Coast Guard and Fleet Technology with some assistance from CANMET to test a variety of welding procedures;
3. Related research between the Centre for Frontier Engineering Research (C-FER), Fleet Technology, the Welding Institute of Canada, the Canadian Coast Guard, and CANMET, to test weld metals and heat-affected weld zones; and
4. Research between Stelco, Algoma Steel, Canadian Liquid Air (CLA), Lincoln Electric, Fleet Technology and CANMET.

In the section that follows, each of these research projects (or phases of the weld corrosion research) is described, along with its costs. The benefits associated with this work have accrued to each of the participants, based on the full complement of the research phases. Benefits are described in a subsequent section of the findings.

Research Components and Costs

Stage 1: Algoma Steel, CANMET and Fleet Technology

The first stage involved a project undertaken by CANMET in 1984 with 50% matching costs by Algoma Steel. Fleet Technology was involved in the research which tested 11 different steels to identify their resistance to weld zone corrosion under test conditions. Traditional welding of steels with 1% manganese content had resulted in accelerated corrosion throughout the weld zone. Stronger steels were being sought, but this first stage of testing confirmed that higher concentrations of manganese (at or above 1.4%) resulted in higher corrosion levels of the steel. These higher corrosion levels were evidenced as V-shaped corrosion, primarily in the heat-affected zone, (i.e., closer to the steel than the welding) when the manganese content of the steel was raised. The research found that a manganese content of 1.1% was actually the optimum level, above which corrosion in the heat-affected zone increased.

Under the first project, roughly $130K was spent in 1984; 50% by CANMET and 50% by Algoma (or $168K in 1990 dollars). An additional $30K was provided as in-kind contributions by CANMET ($39K in 1990 dollars).

Stage 2: Canadian Coast Guard and Fleet Technology

A related research project was begun in 1986. It involved financial support directly from the Canadian Coast Guard. CANMET served as the scientific authority for this work, with testing done by Fleet Technology of Kanata. In this work, the focus changed to corrosion performance of existing welds in need of repair. Three steels were used and an array of welding procedures was tested. In this work, Grade A steel (low in manganese) was again found to have lower levels of corrosion. Welding procedures did affect corrosion, but only as a secondary order impact.

In this second research project, initiated in 1985, the Canadian Coast Guard provided $120K (or $149K in 1990 dollars) to Fleet Technology. A small amount was also contributed by CANMET, for serving as the scientific authority on this work.

Stage 3: Other Projects

Other smaller research projects were also initiated during the mid-1980s, which contributed to Canadian expertise in corrosion resistance for ice-breaking ships. CANMET, the Centre for Frontier Engineering Research (C-FER), Fleet Technology, the Welding Institute of Canada and the Canadian Coast Guard have been involved in these projects to test weld metals, and heat-affected weld zones in a systematic way.

These projects are not included within this benefit-cost analysis, as they have received limited CANMET funding. They are mentioned here, however, because they illustrate the continued interest in, and developments within this area of research.

Stage 4: Polar 8

In 1986 CANMET, Algoma, Stelco, Canadian Liquid Air, Lincoln Electric and Fleet Technology developed a research project to develop a steel for the Polar 8 ice breaker that would reduce corrosion potential, while recognizing the influence on corrosion of welding materials. The project was ultimately approved in 1988, with most of the work being undertaken in 1989.

Project costs were split between CANMET and the industrial participants (i.e., the steel producers and the electrode manufacturers). Stelco served as the project administrator and, along with Algoma, provided the steel samples. Canadian Liquid Air and Lincoln Electric provided the electrodes and looked at the different procedures for welding. Two sets of samples of welded steel plates were produced. One set was tested by Fleet Technology using their anodic dissolution testing procedures[2], and the other was tested by CANMET using their tank test facility[3].

This stage of the research involved joint government and industry funding. As originally designed, the project called for $185K of which $58K was paid by CANMET, through the Department of Supply and Services, $117K was to be paid by Stelco, and $10K was scheduled as in-kind contributions by CANMET. Most costs were expended in 1989.

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[2] This is a form of electro-chemical testing done over a relatively short-term - 15 day period.

[3] In this testing facility, steel plates containing welded sections are mounted on a wheel 1.12 m in diameter and rotated at approximately 80 rpm in a tank containing salt water. Water temperature and aeration conditions can be controlled in the tests.

Of the roughly $58K of federal government money, $23K was paid out to Stelco, $20K to Algoma, $2K to Canadian Liquid Air, $3K to Lincoln Electric in proportion to their level of involvement on the project. Approximately $10K was also paid to Fleet Technology for testing steel plate samples, on a fee-for-service basis.

Stelco, therefore contributed nearly 80% of their costs to the project, or $94K. Other industrial partners (except Fleet Technology) also spent more on this research than they received in compensation from the federal government. Canadian Liquid Air estimates that its in-kind contributions for this project averaged about $18K (87% of its total costs). Applying an 80% rate for contributions from Algoma and Lincoln Electric (the same rate as indicated by Stelco) we find an additional $92K of corporate contributions to the project costs. Given the higher CLA rate of contributions this is likely to be a conservative figure.

As shown in Figure 1 below, the total cost for these three CANMET weld zone corrosion research projects is therefore calculated at $641K (in 1990 $). Of this amount CANMET costs were equivalent to $163K (or $195K in 1990 $) and total federal government costs[4] were $283K (or $344K in 1990 $). Federal government support for the total research package, therefore, represented nearly 54% of the total costs. The aggregate numbers mask an important distinction, however. On Project 2 (with the Canadian Coast Guard and Fleet) the federal government paid 100% of the costs. On Projects 1 and 4, CANMET paid 59% and 25% of the costs respectively, giving much greater leverage on the federal dollars involved.

No environmental or health and safety costs have been identified by any of the participants in this work.

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[4] This includes CANMET support as well as Canadian Coast Guard costs.

FIGURE 1: COSTS FOR CANMET RESEARCH ON REDUCING WELD CORROSION ON ICE BREAKERS

Project	Year	Current $ Costs	1990 Constant $
#1-Algoma/CANMET			
Direct costs	1984	$130K	$168K
In-kind contrib.	1984	$30K	$39K
#2-Can. Coast Guard/ CANMET/Fleet direct costs	1985	$120K	$149K
#4-Stelco/Algoma/ CANMET/ Lincoln Electric/C.L.A./ Fleet - direct costs	1989	$58K	$61K
in-kind contrib. - CANMET	1989	$10K	$10K
in-kind contrib. - industry		$204K	$213K
Total Costs of Weld Corrosion Research		$552K	$641K

Benefits

The benefits of this research vary significantly for each of the participants, and most are not easily quantified.

Within CANMET and the Canadian Coast Guard, officials believe that the research has helped to improve the safety of ice breakers, through improved specifications for repairs or future building of new ice breakers. Because of its involvement in the research work, the Canadian Coast Guard is aware of the findings and is beginning to make use of those findings in its repair and maintenance work.

The extent to which steel manufacturers, ship owners, and ship builders are able to benefit from the results of this work is not clear, however. Algoma has sold $1 million of low manganese steel for the recent repairs of the M.V. Louis St. Laurent (a contract which might have gone to a Japanese firm without the new specifications for lower corrosion steel). Our findings suggest that with the exception of this sale, the steel manufacturers have not made widespread use of the results of this work, and the findings have not been widely distributed to ship builders[5] or ship owners. The knowledge gained from this research is known to the marketing groups at Stelco, Algoma, CLA, and Lincoln Electric. These firms, however, serve primarily North American markets, where there has been limited demand in recent years for ice breaker repairs or building.

Both Algoma and Stelco officials have indicated that they went into this research (with CANMET) expecting to produce information on preferred welding techniques for customers to use on their existing steel products. Neither of these firms claims to have been developing new steel products, or new markets for their products. Algoma produced a new low corrosion steel for the Louis St. Laurent repairs, at the request of the Canadian Coast Guard, but has not marketed it further.

When the Polar 8 ice breaker was put on hold, and requirements for the Hibernia project were changed, the steel companies saw that the market and the need for marketing materials would not expand as anticipated. While they do now have a better knowledge and understanding of which steels will perform best under cold, abrasive conditions, they have had limited opportunity to apply that information to sales of their steel products.

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[5] Two conflicting views were expressed by the participants to this research. The first was that ship builders may be resistant to specifications that will limit corrosion, and thereby limit the demand for future ships or repairs. The second was that any ship builder could develop a specialized capability of building ships resistant to corrosion, and thereby generate additional sales based on that specialization.

Both Algoma and Stelco have suggested that the current benefits of the work are small, if there is no call for the building of any new ice breakers.

For Lincoln Electric there is a similar perception that without the development of the Polar 8 there are no benefits resulting from this work. Canadian Liquid Air, on the other hand, has developed a new electrode (the RCR electrode) through this work. The RCR is an electrode which CLA has commercialized during the last five years. This electrode has been used for ice breaker repairs and gas pipeline repairs, where nickel electrodes aren't useful. Financial benefits from the sale of this electrode have offset the in-kind contributions ($16K-$20K) that Canadian Liquid Air made to the fourth stage of the research, and has provided some limited additional revenues. According to company officials approximately $18K in sales per year (1987-1991) have been realized from the RCR electrode.

For Fleet Technology the benefits of this research are seen in contract dollars and the development of expertise on corrosion resistance in weld zones. During the early stages of the research a corrosion engineer was hired by the firm, but that person has since been let go, given the lower current level of work in this area. Current work on resistance of welded pipes to corrosion relies on the procedures developed in the earlier work.

The Canadian Coast Guard, however, has probably benefitted more than any of the industrial partners. It now has a better awareness of how to slow the corrosion process, and thereby reduce maintenance costs for icebreakers. The rewelding of the bow of the M.V. Louis St. Laurent in 1991-92, has used the results of this research for rewelding and for replacement steel. As rewelding on other ships takes place, long-term maintenance costs are expected to decrease. It is premature to estimate specific financial savings, but some are clearly expected.

Other Findings

Several of the people interviewed for this study indicated that the test results of this work had not been distributed to ship builders or ship owners, other than the Canadian Coast Guard. This lack of distribution of test results has probably limited the export of Canadian expertise and products. Potential benefits coming from this work have, therefore, been limited.

The research on weld corrosion for ice breakers was designed to purposely include as many industrial participants as possible, so that the resulting technology would be widely used. The information and technology that was developed is publicly available; results have been published. However, with the exceptions of the use of the technology on Canadian Coast Guard ice breaker repairs, the development of a new electrode, and a new application of the technology for northern pipelines, industry has not made use of it.

Industrial participants, in general, have perceived the work as being only suited to ice breakers and off-shore rigs. But without further marketing of the technology, or publishing of the results in trade journals (rather than government publications and scientific journals), international ship builders and ship owners are not likely to learn about the findings. Nor will they specify steel grades, electrodes and welding procedures now known to reduce weld corrosion.

Export sales potential has similarly been limited. As one industrial participant explained, if the technology isn't used extensively here in Canada, industry probably won't try to export it. Yet it is quite probable that markets exist in other countries for ice breakers (building or repair), other Arctic or Antarctic applications, and other fields altogether (as CLA's pipeline usage has proven).

This whole set of research projects was initiated because Norway had proprietary information, which Canada had to re-invent in order to use. CANMET, therefore, has helped to develop a relative international advantage, as one of only two countries where low-corrosion steels can be produced for ice breakers. The firms involved in this research should have competitive advantages for contracts on the ice breaker repair (or building) outside Canada.

The value of this competitive advantage, however, is diminishing over time, given the fact that the findings of the Canadian research have not been held as proprietary information. Japanese companies, for example, are known to be currently picking up on the low-corrosion research work.

Several participants to the research suggested that one of the greatest benefits of the work was that it was a cooperative research project involving a number of firms from the same industries. The recognized ability to work together with competitors is something that was noted having future value for the industry.

5. CONCLUSIONS

The financial summary of costs and benefits shows:

Participant	Costs (PV)[@]	Benefits (PV)[@]
CANMET/ Govt. of Canada	$175K	$0[6]
Canadian Coast Guard	$149K	unknown[7]
Industrial partners	$317K	a: ~$200K[8] b: ~$1,100K[9]
TOTALS	$641K	a: ~$200K b: ~$1,100K

[@] Reported in 1990 constant dollars, and rounded to the nearest thousand (000).

[6] Some indirect benefits through reduced foreign procurement for icebreaker maintenance.

[7] Health and safety effects from safer ships, at least for those using new technology identified through this research. Expected to reduce maintenance costs in the long term.

[8] The lower estimate includes $100K for the benefits to date for the companying applying the electrode technology to pipelines, and $100K assumed margin at 10% on the $1M order sold by Algoma to the Canadian Coast Guard.

[9] Same as "a", except that the full $1,000K is counted as a benefit, assuming that the entire order would have been placed outside Canada if Algoma hadn't used this technology. While not a net benefit by itself, the full order was spent in Canada, making it an incremental national benefit.

Two scenarios are shown, based on different treatments of Algoma's $1M sale for the St. Laurent repairs. Scenario a) assigns only a 10% profit (or $100K) to Algoma as a benefit. Scenario b) assigns the whole contract as a benefit, since most of Algoma's expenditures are in Canada and the contract would otherwise have left the country. While a) is the more normal treatment, the particular circumstances of the situation indicate b) should be used here.

Net Present Values: a) <~$441K>; b) +~$459K.

Break-Even/Payback: a) Negative and not expected to improve under current economic conditions. One major oceanic steel construction project, however, would make the difference. b) 1-2 years

Estimated Rate of Return: a) negative; b) 9%, over eight years since the beginning of the work; 36%, if charged only to the two years since the work was finished.

This research has resulted in positive findings that can be applied to ship building and repairs. Maintenance costs of ice breakers and other structures that are subject to cold, salt water, abrasive conditions can be reduced significantly by application of the technology.

The knowledge developed by this research has, as intended, led to improved specifications for the current retrofit of the M.V. Louis St. Laurent, and is expected to produce some (undefined) savings on future repairs to Canadian icebreakers.

Unfortunately, the demand for new ice breakers has been limited by economic conditions, and the initially foreseen payback on the research investment has not materialized. In situations like this, the value of research can be put into one of four categories. These include:

1. Research applied to other applications, development of new products making use of the original knowledge gained, with positive value arising.
2. Research seen as a contribution to knowledge: applied research turns into basic research with benefits only through enabling other developments;
3. Research put on the shelf, with depreciation to $1 over time due to other technological advancements or competitors making use of the research;
4. Complete write-off, with $0 value;

One industrial partner has developed a new product (value type 1 above), which has generated new revenues and moved it into new application areas (e.g., pipelines). The other companies have developed better capabilities, but have largely been unable to find markets for them (value types 2&3). Overall, there is a sense that the benefits have been less than the costs.

Potential benefits still exist, but they are depreciating value over time. Most all of the respondents feel that the real pay-off is dependent on commissioning Canadian ship-building projects which use the technologies specifically developed for highly corrosive ice conditions. Since the major projects planned at the initiation of the research have since been suspended indefinitely, so the major benefits are also presumed to be suspended indefinitely. With the passage of time, the value of the research for Canadian industry will decline.

No export markets have been identified, probably because none of the direct participants seems to have a mandate or incentive for exports. None of the participants has a clear mission to develop the technology for export.

The projects, while technologically competent, appear to be cast in a very specialized role. Further, they now appear to be held largely by organizations doing relatively little to extend the value of the research in either applications or markets. The value of the research is still realized for the Canadian Coast Guard, as it has the knowledge to reduce its maintenance costs for the foreseeable future. But with only one ice breaker being repaired every few years, this is not a sufficient market for the companies involved in the research. As a result, the full potential value of the research must now be considered to be depreciating and any advantages gained by Canadian industry from participation in it will, in time, be dissipated. Where the R&D stimulated by CANMET and the Coast Guard effectively created a Canadian industrial advantage, that opportunity, to date, has not been fully realized.

CHAPTER 13

SUMMARY OF FINDINGS AND CONCLUSIONS

SUMMARY OF FINDINGS AND CONCLUSIONS

This chapter provides an overview of the impacts that the projects have had, in both quantitative and qualitative terms, and the overall conclusions.

SUMMARY OF FINDINGS

Economic Returns

The Terms of Reference for this assignment requested the calculation of Net Present Values and Internal Rates of Return for each project. The Table on the following page summarizes those calculations. Each line is developed in more detail in the earlier case study chapter. NPVs and IRRs could not be meaningfully calculated in many cases. In several cases where the ratios could be calculated, they only partly reflect the value of the projects. That standard financial ratios may be misleading has been confirmed here. The question which remains is: "Is there any pattern in the outcomes which would lead to useful management guidelines?"

Patterns of Outcomes

We examined the different types of activities included in this study to see if that affected the outcomes. The range of outcomes is very wide, when known, and does not appear to be patterned on the type of activity.

Similarly, the degree of knowledge about outcomes also does not seem to have any obvious correlation with the type of activity. We had expected that service activities might be better known, more routinized, than research activities. That does not seem to hold up either, although the research intensive activities appear to have the least certain short-term outcomes. Projects such as Weld Zone Corrosion, Gamma Ray Detection, and Revegetation of Uranium Tailings have relatively little to show yet in terms of quantifiable economic impacts, but they clearly have the potential for very large returns in the foreseeable future.

Summary of Net Present Values and Internal Rates of Return

Project	Types	Dates	Direct Costs[1]	NPV	IRR
Wood Waste Boiler	Contribution	1984	$868K	>$700K	>30%
Solarwall	R&D, demo	1984-	$2,100K	>$2,400K	positive
Split Set Slings	R&D, demo	1987	$11K	$345K?	ca 4000%
Gamma Ray Detection	R&D, demo	1980-88	$1,700K	N/A	negative
CANSPECS	Service	1980-	$1,500K	$millions	>100%?
Tailings Revegetation	R&D, demo	1970-80	$3,000K	unknown	positive
Mine Conveyor Belts	Service	1987-	ca $1,100K	unknown	N/A
Intl. Stds. Setting	Service	ongoing	ca $2,000K/yr	unknown	N/A
Image Analysis	Service	1983-	$4,250K	$millions	over 100%
Mobile Foundry Lab	Service	1984-87	$2,200K	a: $1,000K b: $3,000K	10.5% (4 yrs) 25% (6 yrs)
Weld-Zone Corrosion	Research	1984-89	$640K	a: -$441K b: +$459K	negative +9%
TOTAL			$17,369K +$2,000K/yr.	large	large

Similarly, there does not appear to be a useful correlation between the magnitude of the investments and either the magnitude or the likelihood of paybacks.

Despite the small sample of only eleven projects being reviewed, it is surprising that several aggregate data hypotheses seem to have been refuted. It is clear from this analysis that many broad generalizations about CANMET investments and their returns are likely to be unfounded. That finding leaves us with a more limited opportunity to draw insights from the case studies.

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[1] Calculated in 1990 dollars, converted according to StatsCan's normal inflator-deflator tables.

Case-Level Insights

At the case level, there are several useful insights. The cases are organized here in what is often perceived to be an ascending hierarchy of development:

A. Research;
B. R&D with demonstration;
C. Post-demonstration incentive contribution;
D. Market-oriented services; and
E. Regulated or Public Goods Services.

The Summary Table on the following page has been re-organized in the same manner.

A. Research

The research project, Weld Zone Corrosion, has produced definable benefits. It has created new technological capabilities. Most of its value remains latent, however, as there have been very few uses for the technology yet. Major uses are possible and significant improvements in its payback might occur in the next 5-10 years. As research goes, the present status seems good, and the prospects excellent. As applied R&D, which it was thought to be when it was begun, it has fallen well short of the expected benefits due to postponement of the projects to which it was to be applied.

B. R&D with Demonstration

Four other R&D projects were followed through to the demonstration stage. CANMET has been quite effective in stimulating new knowledge for applied purposes and carrying the technologies forward far enough in the development sequence to put effective pilot plants and demonstrations in place. In all four cases, however, it is important to note that "demonstration" means primarily technical demonstration, rather than market demonstration. CANMET's support carried through the proof of concept at the engineering level, with attached financial analyses. Only in the case of Solarwall did we

Summary Table (by type and start date)

Project	Type	Dates	Direct Costs[2]	NPV	IRR
A. Weld-Zone Corrosion	Research	1984-89	$640K	a: -$441K b: +$459K	negative +9%
B. Tailings Revegetation	R&D, demo	1970-80	$3,000K	unknown	positive
Solarwall	R&D, demo	1984-	$2,100K	>$2,400K	positive
Split Set Slings	R&D, demo	1987	$11K	$345K	> 100%
Gamma Ray Detection	R&D, demo	1980-88	$1,700K	N/A	negative
SUBTOTAL			$6,811K	>$2,745K	positive
C. Wood Waste Boiler	Contribution	1984	$868K	>$700K	>30%
D. CANSPECS	Service A	1980-	$1,500K	$millions	>100%
Image Analysis	Service A	1983-	$4,250K	$millions	> 100%
Mobile Foundry Lab	Service A	1984-87	$2,200K	a: $1,000K b: $3,000K	10.5% (4 yrs) 25% (6 yrs)
SUBTOTAL			$7,950K	$millions	large
E. Intl. Stds. Setting	Service B	ongoing	ca $2,000K/yr	unknown	N/A
Mine Conveyor Belts	Service B	1987-	ca $1,100K	unknown	N/A
SUBTOTAL			>3,100K	unknown	N/A
TOTAL			> 19,400K	large	large

see strong evidence of a market success, and that seems to have been well outside CANMET's involvement. Yet even Solarwall has struggled into the market at a rate much slower than expected by the engineers and financial analysts. The other cases show signs of the same problem, despite strong technologies which appear to be ready for huge markets. All have much potential, yet little seems to have been realized to date.

Economic success requires market success. And that means involvement with buyers' psychology, with corporate investment decisions, with service and support networks, with development of a delivery organization. Rarely do technology-based demonstration programs accommodate these additional steps. From these cases, it seems CANMET is no exception.

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[2] Calculated in 1990 dollars, converted according to StatsCan's normal inflator-deflator tables.

C. Post-demonstration incentive contribution

The Wood Waste Boiler project was justified as a capital contribution to spur adoption of a proven technology, in order to reduce national costs for imported oil and to increase security of national energy supplies. While those results were achieved, a much larger benefit occurred through an apparent demonstration effect, leading to the widespread adoption of the technology. In this case, the benefits are real and can be documented.

In our opinion, having evaluated several other demonstration programs supporting innovations in technology, this result should not be considered accidental. Effective demonstration effects appear to take place fairly often later in the adoption cycle than program planners expect.

D. Market-Oriented Services

Three cases could be considered as market-oriented services. CANSPECS, Image Analysis, and the Mobile Foundry Lab all make use of CANMET's technical expertise and equipment to provide specialized testing and research services for an industry. CANSPECS provides calibration services for the coal testing labs. Image Analysis provides highly specialized analytical services for the hard-rock mining industry. The Mobile Foundry Lab provided process and chemical analyses for foundries, primarily small and medium-sized ones without their own lab facilities or technical expertise.

CANMET's position in providing these services is somewhat delicate. It tries to provide new services which create high leverage returns for industry. They must be both substantially different from existing commercial services and sufficiently broad to warrant the involvement of a public agency, yet they must also be highly effective. All three programs appear to successfully meet these criteria -- a remarkable feat.

While costs are quite well-defined (for both CANMET and other participants), benefits are largely unknown. They are expected to be substantial and real, but the data either haven't been collected or are so confidential that we didn't see signs of them. This lacuna makes it difficult to substantiate the benefits. It also makes it very difficult to answer important management questions about the relative efficiency of different service modes and leverage points. Accordingly, organizational learning can only be intuitive and based on individual situations.

The benefits for CANSPECS and Image Analysis appear to be positive, even without extrapolation from our micro-cases to the whole user population. With extrapolation, the results are so positive that there must be very important lessons for public agencies. The value which appears to be added by these programs would be the envy of many public agencies – or private ones!

The Mobile Foundry Lab is a more controversial case. It was clearly uneconomic for the public agencies which supported it, and was shelved after 1987. An assessment at the time of the program found substantial economic gains to Canada resulting from the work. Yet that study apparently failed to consider displacement effects and total program costs in estimating the benefits, probably overstating the benefits. Our re-examination found no residual incremental benefits being claimed by the industry, although neither the users nor we were able to make any definitive examinations of the program's incremental impacts. Nonetheless, it seems clear that the Lab was very successful in getting better knowledge to the industry, resulting in improvements to most participant's production processes. In a devastated industry, the fact that no new business was attributed to the improvements may be a reversed sign: simple survival has been an indicator of superiority in this industry in the last five years.

E. Regulated or Public Goods Services

The two remaining services, International Standards Setting and Certification of Mine Conveyor Belts, are different. They are not particularly market-sensitive.

In the first case, the service is provided more as an administrative obligation than as a productivity-driven activity. Economic returns are not a direct objective and little measurement of such outcomes is even attempted.

In the second case, activities are mandated by regulation and CANMET has the only test facility in Canada doing the work. In this case, there is substantial recovery of costs, although there appears to be a small public subsidy (i.e., incomplete cost recovery). Perhaps the latter is to ease the burden on the private sector of the costs of regulation, or to recognize the public benefits which underlie the regulatory requirement. Whichever is the reason, CANMET is certainly not extracting monopoly profits. In neither case are the benefits even calibrated.

Overall Summary

It is very difficult to generalize across such a wide range of project types and benefit values. Still, one can see that these eleven projects represent about $25-35 million dollars of Government and participant direct costs over the last 20 years.

They have already generated many millions of dollars of benefits, probably several hundreds of millions. Many are only partially developed on the benefit side, and almost fully amortized on the capital procurement side. The potential for further strong benefits is quite large.

At the same time, it is apparent that many of the economic benefits are not being realized because of a lack of follow-through by the participants. Thus additional latent benefits are probably at least as great again as the ones already achieved.

Environmental values appear to be strongly served in this sample of projects. There are very few environmental costs and many benefits, some of them quite large, tentatively measured in the millions or billions of dollars.

Health and safety benefits are relatively uncommon, and health and safety costs practically non-existent in this group of projects. In some cases, such as Gamma Ray Detection, the costs are not well known because they involve low-level long-term effects, a class of phenomena which is not yet well understood.

Health and safety benefits do appear as significant on about half of the projects reviewed; in only one (Mine Conveyor Belts) are they the dominant benefit.

Overall, these CANMET projects demonstrate strong leverage and potential for future improvements.

CONCLUSIONS

The following conclusions draw on all of the cases to provide insights about the state of technology development and management in CANMET. The discussion is presented according to key topics.

Outcomes Analyses

Projects are approved because their proponents satisfy authorities that the expected benefits are worth pursuing. In an environment such as CANMET's, new technologies or procedures must be developed in order to deliver the forecast benefits. In a research-strong organization, we should expect some outcomes to deviate from forecast. Issues that are important enough to be worth trying to solve are often ones associated with a significant uncertainty. Thus, as research progresses, new evidence may reveal new issues or solutions which were not previously known. Some may be dead-ends, others tangential, and still others may produce major expansions. If all projects worked out as expected, it would be a sign that only well-understood problems were being addressed, in turn raising questions about the value of their solution. Accordingly, a healthy and innovative organization should expect some results to deviate from expectations.

The historical reviews revealed a range of results, from highly stimulative work (many follow-ons) to projects which have not realized their potential. Five different types of outcomes were identified; some projects had more than one, based on different results for different objectives. Most projects have worked out more-or-less as expected, a significant accomplishment given the risks associated with innovation. The five outcomes are:

- HIGH LEVERAGE: CANMET funds triggered significant follow-on expenditures and further investments.

* TAKE-OFF: CANMET funds initiated a process which has since become self-sustaining growth, without further public funding.

* LOCALIZED BENEFITS: Specific benefits for a local area or industry, with little extension to other areas or sectors.

* STEADY DEMAND: CANMET has created a sustained activity which is apparently based on a stable demand.

* LESS THAN EXPECTED: At least one important expected benefit has not materialized in the time frame originally anticipated.

The table below illustrates the range as well as the consistency of CANMET's results, when each of the project's results are compared to original objectives..

MEETING OBJECTIVES[3]

(Extent to Which Original Objectives Have Been Met)

Case	<<	<	as expected	>	>>
Wood Waste Boilers			***	*	*
Solarwall		*	***	*	
Split Set Slings		*	***		
Gamma-Ray		*	**	*	
CANSPECS		*	**	*	
Revegetation		*	****		*
Conveyor Belts			**		
Intl. Stds. Setting		*	***		
Image Analysis			**	*	
Mobile Foundry Lab	*	*	**		
Weld Zone Corrosion	*		**	*	
Tally	2	7	28	6	2

The only type of expected benefit which has a pattern of under-achievement is that of industrial spin-offs. This is the case with the Split Set Sling Trial project, Gamma Ray Detection, International Standards Setting Activities, Weld Zone Corrosion, and in some respects CANSPECS. In retrospect, the expectations for industrial spin-offs on these projects were quite vague, knowledge of the processes needed to realize them was inadequate, and few resources were allocated to deliver them.

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[3] These are subjective judgements, based on our understanding of original project expectations, formal and informal, and the present status of the project. Each "*" represents one objective.

The two objectives scored as falling far below expectations are the willingness of industry to pay the costs of the Mobile Foundry Lab, and the expected spin-offs of the Weld Corrosion research to the Canadian steel industry, arising from the Polar 8 and Hibernia construction projects which have yet to materialize.

One runaway success is the stimulation of follow-on research into groundwater effects of mine tailings, a result of the Elliot Lake revegetation study. Follow-on work to date is an order of magnitude larger than the original work, and still growing, despite having been a very minor objective of the original project. Interestingly, this growth of research reflects the project's failure to control the leaching problem with its relatively simple solutions, thus uncovering a much larger issue. Results of this sort should be expected in any scientific inquiry addressing significant new issues. The real surprise in this review is not the presence of such stimulating failures, but their infrequency.

The other very strong unexpected success was the multiplier effect on adoption of wood waste boiler technology. CANMET funding was not based on a demonstration effect, presuming that such work had already been done. Yet it is apparent that numerous other adoptions, including some export sales, have arisen from the Donohue installation.

This process raises some questions about our understanding of the "demonstration-adoption" process. Results on other demonstration programs have often been frustrating to program managers because adoption rates are much slower than expected.[4] Here we have a strong demonstration effect, despite expectations that it was no longer necessary. While this result may be based on particularly effective personalities or promotion, it is worth examining in more detail to see if a revamping of technology demonstration programs to cover later parts of the adoption cycle would accelerate transfer of new technology into industry.

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[4] Comments based on previous work in evaluation of technology transfer programs in energy and agriculture.

Overall findings show that the lack of a proactive agent has damaged the agency's impacts in some areas of technology transfer. However, active CANMET personnel have tended to continue to attract opportunities.

While CANMET partly reflects a broad malaise within the Canadian public sector with respect to the development of intellectual property, it has accomplished much. Creation of intellectual property appears to have been strong, and recognition of valuable technologies in industry has also been above average. Better definition of the agency's role as a generator and agent of technological change, combined with appropriate resources dedicated to maximizing those impacts, would make the agency even more effective.

Cost Recovery

For services that can be routinized, cost recovery has been implemented fairly effectively. For services like Image Analysis and Conveyor Belt testing, costs have been defined, prices set, and an effective business service created. Pricing seems to have been market-sensitive, recognizing alternative services as well as CANMET's special capabilities. In some cases, recovery may have more than covered operating costs; in others, a partial subsidy appears to have justification to reflect other corporate or governmental goals. Sustained programs have subsidies which match their justification, even if a precise value cannot be established.

Where it was discovered that unacceptable subsidies have been required (e.g., Mobile Foundry), programs have been suspended or restructured. This use of attempted cost recovery matches industry's use of various pricing mechanisms to develop empirical market information. "Sometimes, you only find out what it's really worth when you start charging for it."

Cost-Sharing

In other areas, effective cost-sharing relationships have been created. With CANSPECS, for example, all parties seem reasonably satisfied with the returns for their contributions, yet CANMET has no direct recovery of its costs. The same holds true of the Split Set Slings trial in Cape Breton and the Solarwall project.

Reviewing such cases as Image Analysis, Mobile Foundry, and Conveyors Belts, we were pleased to see a relatively sophisticated pattern of service development. In each case, an industrial need was identified, a service developed, introductory pricing initiated to build business, then a decision made to continue, contract out, discontinue, or restructure.

In the case of Image Analysis, capital costs have been carried by CANMET. Operating costs were subsidized by the START program for the first two years, and have since been carried by the mining industry.

With the Mobile Foundry, the introduction of limited cost recovery very quickly showed that the industry being served was not willing to pay anywhere near the full costs of the program. The program was then mothballed. One study at the time showed that indirect returns more than covered the deficit on the program; our current analysis shows no such return. (Any reintroduction of Mobile Foundry services in the future should consider options which significantly reduce operating costs while preserving the most valuable parts of the on-site service.)

CANMET's role in the testing of mine conveyor belts is primarily mandated by regulation. Operating costs are split with the industry, presumably because there is some general public good being served. Demand and operations appear to have reached a steady state.

We did not review any cases which suggested that cost recovery was designed to cover development costs as well as operating costs.

There appear to be some outstanding issues for the organization. The relationships among service provision for fees, public service, research, and new product/service development are still being worked out. Funding and performance guidelines do not yet appear to have dealt with this complex interaction in a sophisticated way.

The extent to which normal business practices, like "cash cows" funding new product development, apply to CANMET services is still unclear. It affects pricing as well as development. Yet the answers are not simple for a public sector organization. They are even more complex for an advanced technological organization, such as CANMET, where new developments are both expensive and risky. The potential for good ideas to lead into either windfalls or write-offs is very high. Treatment of both the risk and the rewards is needed to provide a sound financial framework as well as providing clear and fair direction and performance criteria to staff.

Other Types of Recovery

The Gamma Ray case was very important to this work because it revealed a second dimension of recovery models. By imbedding the gamma ray technology in a larger technology (CANMET Hydrocracking), then licensing the hydrocracking package, CANMET demonstrated another way to recover costs (or provide returns to investments in R&D). The creation of special technologies is clearly a CANMET strength, yet operating them as an industrial service is not always attractive either to users or CANMET. Licensing, with various royalty options, makes an attractive alternative.

Our overall review suggests that there is much more potential for this type of wealth creation and sharing than is presently being exploited. Indeed, it appears that some technologies (e.g., Split Set Slings, Mobile Foundry, Weld Zone Corrosion) could be producing much more valuable returns to CANMET and Canada if they were deliberately developed as licensable technologies and turned over to a proactive champion.

The whole area of public sector involvement in intellectual property is poorly understood and very under-developed at this time. Yet several models are being created and tested in various federal, provincial, university and private agencies.[5] There is significant potential for CANMET to increase its revenue, and to increase its contributions to Canadian industry, by developing a more effective push to get its technologies to market.

Roles for Partners

CANMET engages in many partnerships. Most involve co-funding arrangements. The terms and productivity of those partnerships are very diverse, as befitting so many different kinds of relationships. Yet there are some patterns which emerged from our case studies.[6]

Development of a specialized service capability, designed to support firms across an industry, makes service clients of the industrial partners. This model can be applied to Image Analysis, Mobile Foundry, Conveyor Belt testing, and may come to be the dominant model for the Gamma Ray capability.

In other cases, joint development of new technologies is one way to create new industrial capabilities in Canada. Solarwalls, hydrocracking (including Gamma Ray detection), Revegetation of Uranium Tailings, and Weld Zone Corrosion are all examples of efforts of this type. CANMET has provided funds, technical expertise, and specialized equipment in partnership with industrial efforts. Industrial participation is expected to lead to practical applications and demonstration of proof-of-concept. The challenge in these types of partnerships seems to lie more in the push to commercialize the results, rather than the creation of effective research projects.

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[5] Note the development of intellectual property and technology transfer mechanisms by the Agriculture Development Fund of Saskatchewan. Note also the creation and development of RockCliffe Research and Technology Inc. to spin out technologies from federal labs.

[6] From our point of view, this is a very healthy sign. Partnerships are organized to accommodate the specific capabilities and responsibilities of each participant to contribute to solving specific problems. While this way of doing business makes administration more difficult than standard programs and contractual arrangements, it is more focused and more productive.

Subsidies to stimulate industrial adoption of existing technologies is a third form of industrial interaction. It has been used in the cases of Solarwalls, Wood Waste Boilers, and Split Set Slings. Results have been mixed, largely due to variations in the presence of proponents and their effectiveness in pushing products to market.

Public Goods: Specific Functions

Public goods, such as security of fuel supplies, can be used to justify some unrecovered costs. On the Wood Waste Boilers case, for example, the primary justification would appear to have been the reduction of oil imports. Saving foreign exchange, as well as securing energy supplies from domestic production, would be the primary results. The result was a relatively modest contribution of 10% of the capital costs for installation of a proven technology. (The fact that the St. Thomas Didyme installation appears to have become a highly productive demonstration should be treated as a bonus, since it was not funded for that purpose.)

There are no direct recoveries from this sort of investment. The recoveries come indirectly, through domestic supply benefits, security (unpriced until required), environmental mitigation, employment (avoiding UI/welfare expenses, creating sales and income tax revenue), corporate taxes on increased production, more intensive use of resources, etc. Those recoveries are rarely calculated rigorously.

Public Goods: Diffused Functions

CANMET's contributions to International Standards Setting merit special comment. This case was the most difficult for us to assess. The function is spread throughout the organization and is generally not treated as a

Centre-wide organized activity. It does not have a specific direction, accounting, or reporting focus. While assigning it 1.5% of CANMET's PY allocation makes certain costs calculable, those numbers should have fairly wide confidence bands placed around them.

The most difficulty, however, was encountered in trying to assess benefits in a systematic manner. They are almost all intangible or anecdotal. Even if one was able to quantify a economic benefit from CANMET participation in an international standards body, most such calculations would be trivial or misleading. As a result, we fell back to two qualitative measures. The first was to assess this activity as a type of pro bono or charitable contribution, using various corporate guidelines for comparison. The second was to compare the expected impacts of CANMET participation on economic order in Canada and our trading world with the magnitude of the associated costs.

The pro bono yardstick must be modified for public sector organizations. By their very nature, they function to fill socially valuable gaps in the private sector, and so are expected to have a much higher share of non-economic activity. Corporate standards, when articulated, seem to range from 1-10% of pre-tax profits, with an average goal around 2.5 to 3%. If we use a yardstick of 10% profit on gross revenues, the contributions budgets then becomes 0.3% of gross revenues.

What should be the comparable level for a public sector organization? There are no easy guidelines, except that we would expect it to be considerably higher, by virtue of the purpose of a public sector organization being to fill gaps in the private sector – often the unprofitable or unattributable gaps.

CANMET's International Standards Setting activities, at 1.5% of PYs, are not the organization's only unrecoverable contributions. While the comparison may suggest that this contribution is high, further examination clearly shows that the analogy is largely inappropriate. CANMET has numerous public goods rationales for playing the standards roles its does, and the recovery to Canadian society and industry in health and economic benefits can be quite large, if indirect.

CANMET participation appeared to be largely on well-organized and effective bodies. Their deliberations appeared to be focussed and efficient, producing standards which were widely adopted and helped to rationalize the related activities. In most cases the activities were worth far more than the standard setting costs. Thus, our conclusions, though necessarily vague and general due to the quality of the output indicators, were that the functions were being executed efficiently and professionally, and were likely producing quite high leverage for Canada.

That left us with a somewhat unsatisfactory sense of closure. Evaluation of this type of activity needs better yardsticks. Important questions couldn't be answered. How does one assess the consequences of increasing this activity to 3% of PYs? Cutting it to 1.0%? What are the leverages? How does management decide what is really appropriate? How does management even control and direct such a diffused activity? Such an inquiry is very complex, yet of great value for many public sector organizations. It is clear that justification lies in broad, indirect social benefits, rather than specific direct returns.

A Note on Industrial Intelligence

Part of the justification for participation in international standards setting has been the potential to gather information of competitive value to Canadian industry. As new technologies come before the standards bodies, valuable information about the technologies and optional techniques is revealed. Similarly, as standards are set, they will affect the costs and competitiveness of Canadian firms producing and buying affected products and services. With participation in those meetings, we create the potential to feed such valuable information to our industrial participants. Such an aggregative role is often used as a justification for public participation. Similar roles are routinely expected in the diplomatic and commercial services operated by External Affairs / International Trade.

To satisfy the terms of such support, the activities should demonstrate that this potentially valuable information is collected, processed, and distributed effectively. Unfortunately, there is little evidence that CANMET carries out this full function on any systematic basis. Some staff members undertake this work routinely through extensive interaction with industry, but the transfer process remains largely non-systematic and indirect. This broader role in technology transfer is not universally accepted or carried out. As a result, significant benefits to Canada are not fully delivered.

Impact of Social Benefits

In all eleven cases, the inclusion of social impacts, beyond the direct economic participation of CANMET, significantly strengthens the benefit-cost assessment. Additional social costs are minor, benefits substantial. In all cases, the direct benefits to CANMET are probably less than 50% of the identifiable value. Thus judgements about social value change in all cases for the better. Even in the worst financial case, Mobile Foundry Lab, where recoveries were less than 10% of costs, an earlier study argued that diffused social benefits in terms of increased industrial productivity and competitiveness more than made up the other 90% of costs. At the other end of the scale, the Image Analysis service has resulted in millions of dollars of investments and, we presume, in similar benefits to the industrial participants, their employees, customers, suppliers, and shareholders.

In all cases, precise (or even vague) estimates of value were impossible. What turned up was anecdotes recounting differences in contracts won, businesses saved, plant lives extended, etc. In most cases, even one or two anecdotes would be sufficient to offset the CANMET deficit. There were many such anecdotes and most projects had dozens of clients who appeared satisfied by their experiences.

For analysts used to rigorous, quantified analyses, this level of evidence is far from satisfying. Yet it is the level of evidence available. Using it effectively requires several conditions:

- Examination for trends: i.e., are all anecdotes in the same direction, or do they offset each other, with some being net benefits, others net costs?
- What is the magnitude of the claims?
- What is the likelihood that anecdotes apply to other participants not interviewed? To greater or lesser degrees?
- Are the benefits net of participant and CANMET costs?
- To what extent can effects be attributed to CANMET intervention?
- Should the benefits to one participant be recorded as costs or benefits to other groups in society? If so, to what degree?

To the extent possible in each situation, we tried to examine claims from these angles, to satisfy ourselves about the net effects on Canadian society. While the logic was sometimes fuzzy, and the risks of double-counting often present, we concluded that external social benefits were likely considerably higher than direct returns.

Unexpected Impacts

External events have sometimes significantly affected the benefit function of these CANMET projects. The Weld Zone Corrosion work, for example, was at least partly justified on the basis of expected steel sales for the Polar-8 icebreaker project and the Hibernia offshore development. When those projects were shelved, the research benefits were deferred indefinitely, vastly reducing the expected payoff.

Conversely, heightened concerns about uranium effects and low-level environmental dosage effects in the 1980s has made the early work on revegetation of uranium mine tailings more valuable than expected. Not only were many of the solutions already underway, but the remaining research agenda was much better defined. The value of those benefits may have been anticipated twenty years ago, but was probably understated compared to public concerns in the late 1980s and early 1990s.

A Learning Organization

CANMET has demonstrated the ability to innovate and learn, trying new ways of delivering benefits to its clients, and dropping or restructuring those which cannot be justified. It has also shown market sensitivity in establishing its recovery policies and prices, recognizing not only related competition, but also the value added by the expertise of its professional staff and specialized equipment. While wrestling with some very complex issues in technology transfer, CANMET has shown flexibility and innovation in developing new approaches.

There is room for continued improvement. Tracking social benefits is important to CANMET in order to measure more accurately its real contribution to Canadian society. Increased attention to proactive means of creating the wealth inherent in its research and development projects could add significantly to the value the organization contributes. Further development of the rationales for various levels of public support would aid program managers with decisions about allocation of costs, and hence about the level and type of external support required to sustain programs. Rudimentary models appear to be in place in each instance; now it is time for more detailed and accurate development of these management tools.